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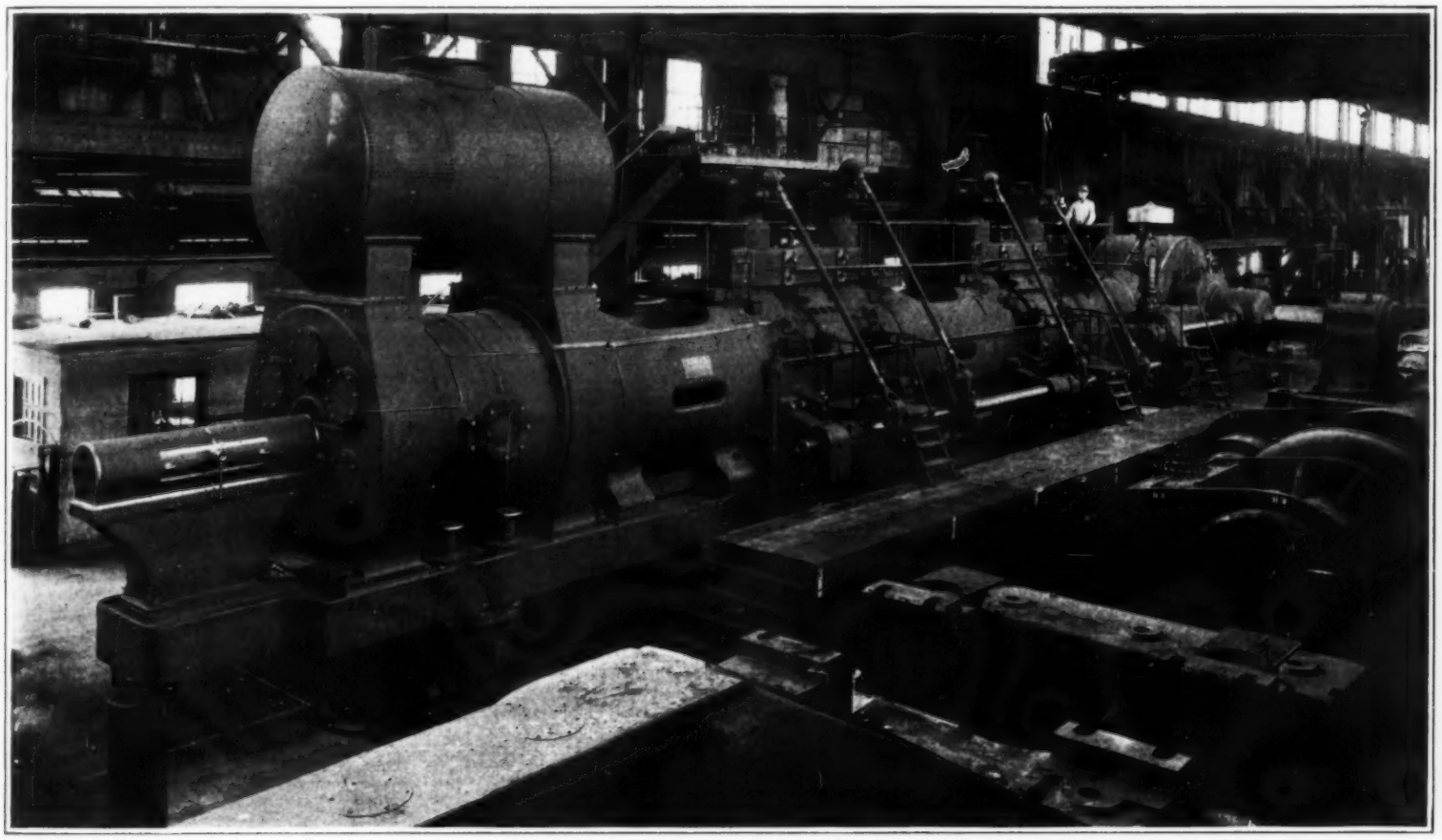
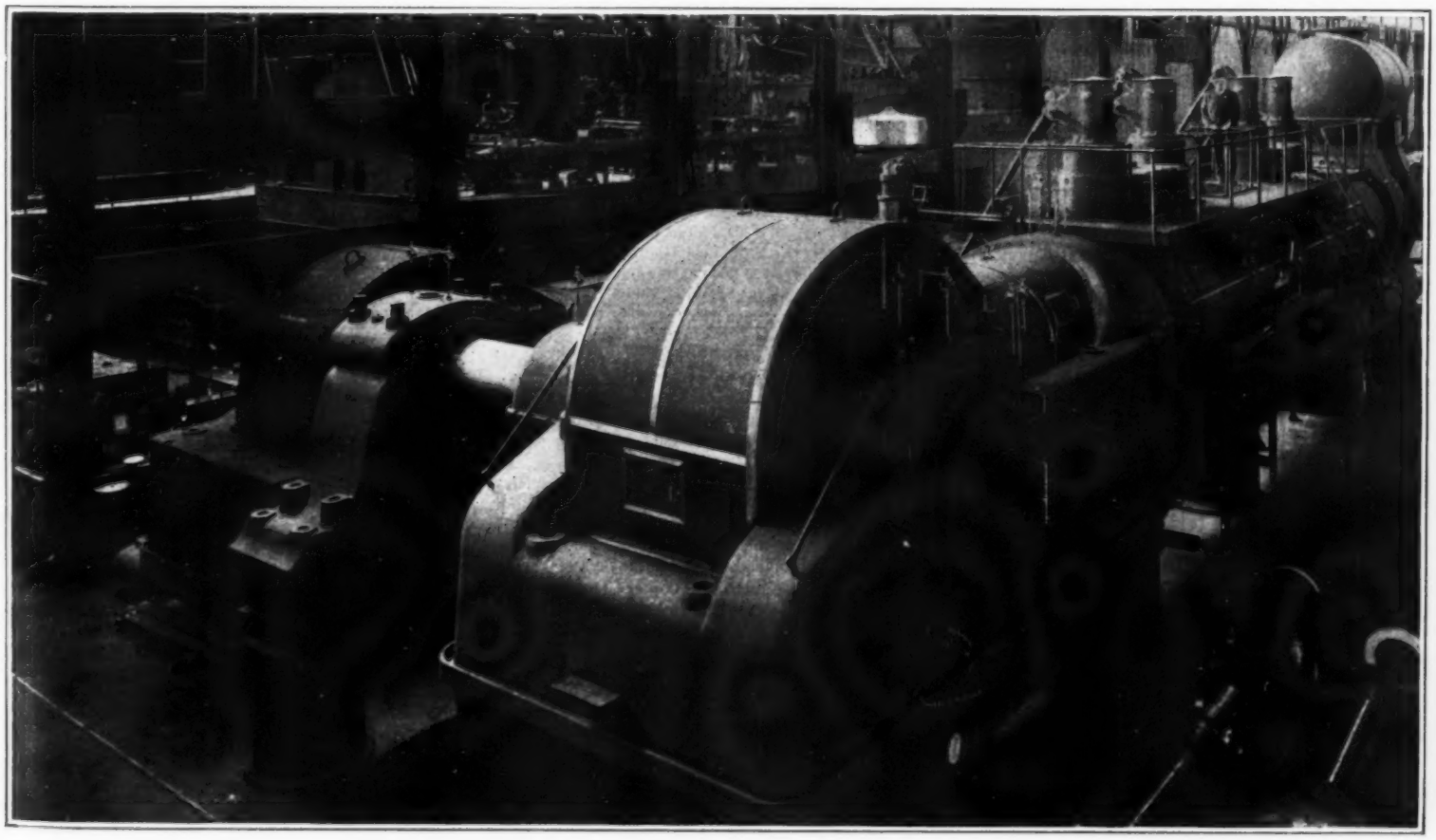


Valve gear side of a big gas engine. Blowing cylinder in foreground.



Crankshaft end of big gas engine.

LARGEST AMERICAN INTERNAL COMBUSTION BLOWING ENGINE.—[See page 407.]

The Chemical Industries of Germany—II*

An Historical Review of Processes and Conditions

By Prof. Percy F. Frankland, F.R.S.

Concluded from SCIENTIFIC AMERICAN SUPPLEMENT No. 2059, Page 390, June 19, 1915

POTASH SALTS.

Germany appears to be alone in possessing vast deposits of potash salts, while the enormous value of these to agriculture was first demonstrated by Liebig and made public by him in his "Application of Chemistry to Agriculture and Physiology" in 1840. This work may without question be regarded as the foundation stone on which agricultural chemistry has been raised.

The celebrated deposits of potash salts were accidentally discovered in 1857, when boring for rocksalt at Stassfurth, near Magdeburg, in Prussia. Their industrial exploitation on an ever increasing scale was begun in 1861 by Grüneberg and Adolf Frank. In 1861 the production of crude potash salts was 2,000 tons; in 1912 it was 11,000,000 tons, worth $44,000,000. Ninety per cent is used as manure (about one third in Germany itself), and 10 per cent in industries (about two thirds being worked up in Germany for carbonate, caustic, nitrate, alum, chromate, and chlorate, etc.). America is now experimenting with a view to obtaining potassium chloride from feldspar by the method used in the laboratory for determining alkalis in insoluble silicates, and which consists in heating the silicate with a mixture of lime and calcium chloride. Whether it has any commercial future remains to be seen.

This is a matter of prime importance in the United States, as potash salts are there used on an enormous scale, especially for agriculture. Thus they consumed in 1900 Stassfurth potash salts worth $4,200,000; in 1910, $12,200,000, and in 1911, $15,200,000.[14]

EXPLOSIVES.

I have already mentioned the importance of nitrates and of nitric acid, and have referred to the employment of the great part in agriculture; of the remainder the major part goes into the manufacture of explosives and into the coal tar color industry.

Black powder or gunpowder is said to have been discovered by the English monk Roger Bacon (1214-1294). Gun-cotton was discovered by Schönbein in Basle and Christian Böttger in Frankfurt in 1846.

Nitroglycerine was discovered by Sobrero in Pelouze's laboratory in Paris in 1847, and first manufactured on a large scale as an explosive by the Swede, Alfred Nobel, in 1862.

The disruptive properties of gun-cotton are greatly moderated by gelatinizing by means of solvents (acetone, acetic ester, alcohol and ether, etc.), and by mixing with nitroglycerine ballistic materials like cordite, and other smokeless powders are obtained. There is another class of explosives which combine great safety in handling with enormous disruptive effect. Picric acid (discovered by Woulfe of London in 1771), but first used by the French under the name of Melinite for filling shells in 1881, and later by the English under the name of Lyddite. More recently this has been replaced by trinitrotoluene, first proposed by Haeussermann in 1891 for filling shells and used by the British Service under the mark "T. N. T." It is even less sensitive to shock than picric acid. "Ammonal," used by the Austrians for shell-filling, is a mixture of T. N. T. with ammonium nitrate, charcoal and aluminium powder. It is both very safe and very powerful. T. N. T. is much used for demolishing bridges. It is so insensitive to shock that it is not exploded on being struck by a rifle-bullet, and when in a shell it withstands the impact of the latter piercing an armor plate.[15]

Tetra-nitro-aniline, obtained by Flürscheim, enjoys the unique position among explosives of having been discovered in this country. It is said to be equally safe and even more powerful than trinitrotoluene.

According to the late Oscar Guttman, the production of nitroglycerine explosives in 1909 was as follows: United States, 20,000; Germany, 10,300; England, 8,100; Transvaal, 8,000; Canada, 5,000; Spain and Portugal, 3,500; Austria-Hungary, 2,300; France, 1,500 tons; Switzerland, Austria, Norway and Sweden, 600 tons each; Russia, Italy, Holland, Belgium, 500 tons each; Greece, 175 tons.

Explosives are of enormous importance also in civil life—in mining and engineering modern explosives have greatly accelerated progress and have rendered possible such works as the Panama Canal. They are also being now employed with great advantage in afforestation for loosening the ground in which trees are to be planted. The manufacture of explosives in Germany is very highly developed. The total German production of 40,000,000 kilogrammes includes dynamite explosives, 10,000,000; ammonium nitrate explosives, 16,000,000 and black powder, etc., 14,000,000 kilogrammes. There were exported in 1908 explosives of a value of about $5,000,000, and in 1912, $15,000,000.

The world production of explosives is now about 400,000,000 kilogrammes, or ten times the German total output. Great Britain has at Ardeer in Scotland, the largest explosive factory (Nobel's) in the world, covering 850 acres, employing 1,800 men and 700 women, and producing annually about 16,000 tons of all kinds of high explosives.

ARTIFICIAL SILK

An eminently peaceful industry which is closely related to that of explosives is the production of artificial silk and celluloid. The manufacture of artificial silk has grown up during the past twenty-five years, for this product was first shown by Count Hilaire de Chardonnet at the Paris Exhibition of 1889; he discovered the method of its preparation while a student in the Ecole Polytechnique at Paris, and in 1891 formed a company at Besançon with a capital of $1,200,000 for its manufacture.

The chief kinds of artificial silk are: (1) Nitrated cellulose (soluable in alcohol-ether) silk (denitrated by ammonium sulphide) (Chardonnet silk). (2) Ammoniocupric oxide cellulose silk (Pauly, Fremery, or Urban silk, of the Vereinigte Glanzstoffabrik, Elberfeld, 1897). (3) Viscose-silk (CS_2 in presence of NaOH or Ca (OH_2) on cellulose) (Cross and Bevan). (4) Acetate-silk (acetic acid on cellulose) (Cross and Bevan).

Germany produces about 2,000,000 kilogrammes, value about $6,000,000, exports 600,000 kilogrammes, and imports 1,800,000 kilogrammes; the imported is principally "alcohol silk," due to disadvantageous alcohol tax in Germany. Germany is the principal user of artificial silk, although the fundamental discoveries upon which the manufacture is based are largely due to French and English chemists. The world production is estimated at about 7,000,000 kilogrammes.

The distribution of the industry may be gathered from the following: France, 7 factories; Germany, 8; Belgium, 3; England, 2; Spain, 1; Austria-Hungary, 4; Russia, 3; America, 3; Japan, 1.

Great profits have been made out of artificial silk (some of the companies paid 50 to 100 per cent dividends), and the price has greatly fallen since its introduction from $7 per kilogramme in 1903 to $4 in 1906, and $3 (poorer qualities $1.50 to $2) in 1910.

The cellulose industries furnish a particularly striking example of the manner in which chemical research and invention are able to enhance the value of the kindly gifts of the earth. Thus, 1 cubic meter of wood has valne as fuel about $1.50; (after boiling with lime, soda and sulphite) as paper pulp, $8; ditto as paper, $14; and as pulp converted into artificial silk, $400 to $1,200.

INDUSTRIES DEPENDENT ON SYNTHETIC ORGANIC CHEMISTRY

It is out of the profound study of synthetic organic chemistry which has been made during the past sixty years that the industries of artificial dyes, drugs, and perfumes have incidentally arisen. The earlier and pioneering achievements in synthetic organic chemistry are well distributed among the nations of Europe,[16] but during the major part of the sixty years the great bulk of the discoveries in this domain have been made in Germany. Organic chemistry is, perhaps, the branch of science which more perfectly suits the German mind and temperament. It involves the possession of those qualities in which Germans are so pre-eminent—the capacity for taking an infinitude of pains, the capacity to anticipate difficulties and organize means to circumvent them. It is, moreover, only possible to make substantial advances in the problems of organic synthesis if the master has at his disposition a number of highly qualified and docile assistants and apprentices; in a word, the master must be at the head of a large and efficient school of research. It is in the possession of such schools of research, both in the universities and in the chemical factories, that Germany has by two generations the lead of all other countries in the world. While most of the professors of chemistry in British universities and colleges have under great difficulties and without any sort of encouragement been more or less successful in building up such schools of research, which are, however, by no means slavish imitations of the German model, the chemical manufacturers of England, have, with some notable exceptions, failed to establish anything worthy of the name of research laboratories in connection with their works.

It is in respect of the works research laboratory that there is the greatest contrast between the chemical industries of Germany, and those of other countries, and it is not surprising, therefore, that the present war should have served to emphasize the class of chemical products for which Great Britain is almost entirely dependent on Germany.[17] It is precisely those products—artificial dyestuffs, artificial drugs and artificial perfumes which are the outcome of the works research laboratories, that are now in many cases unobtainable in consequence of the cutting off of the German sources.

The seriousness of the situation is apparent from the following figures, relating to dyestuffs alone: The value of dyestuffs consumed in England annually is $10,000,000, and the value of trade in which these dyestuffs are employed is $1,000,000,000, while upwards of 1,500,000 workmen are dependent upon these industries. The total value of dyestuffs imported into the United Kingdom in 1913 was $9,460,275, of which Germany contributed $8,654,105.

Perhaps the most concise way of conveying a superficial idea of these industrial products of organic synthesis will be by means of the following classification:

I. *Artificial Products.*—Colors first obtained from aniline by Runge in 1834, by the action of bleaching powder. Aniline colors: Mauve was discovered by Perkin in 1856 and Magenta by Verguin in 1859. Azo-colors[18] were discovered by Greiss in 1859, and introduced on an extended scale in 1878. The azo-colors have achieved an enormous importance and have practically banished cochineal and logwood from the dyeworks. Some 2,000 azo-colors in use. Congo-colors, substantive cotton dyes, were discovered by C. Böttiger in 1884.

It must not be supposed that British color manufacturers have been idle from the days of Perkin; thus in 1880 a very original departure was made by Messrs. Read, Holliday and Sons, who introduced the principle of developing azo-dyestuffs on the fiber with their so-called ingrain or ice colors. Some of these have achieved a great success, thus 2,000 tons of p-nitraniline are now annually manufactured for the production of nitraniline-red and similar colors.[19] Again, the discovery of primulin and the colors which can be derived from it, by A. G. Green in 1887, is another very notable achievement.

Eosin colors were discovered by Caro in 1873.

II. *Artificially Produced Natural Products.*—This group contains substances occurring in nature and long valued by man. The chemical nature of these substances has been carefully ascertained by chemists who have then deliberately set to work to devise means for their artificial preparation at such a cost as to compete with and ultimately supplant the natural product. These campaigns against the commerce in the products of nature undoubtedly constitute one of the most remarkable phenomena in the history of the world. Bear in mind, it is the production and supply to man of the actual products of Nature, but more cheaply than they can be produced and supplied by Nature herself. These endeavors have already been successful on a very large scale.

Alizarin (the essential principle of the madder root) was first synthesized by Graebe and Liebermann in 1869. At the time of this discovery, the world production of madder was 50,000,000 kilogrammes roots (1½ per cent alizarin), representing 500,000 to 750,000 kilogrammes alizarin, value $11,250,000. In 1870 France had 20,000 hectares (50,000 acres) under madder cultivation, which soon disappeared after the introduction of the artificial product.

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*A paper read before the Birmingham section of the Society of Chemical Industry, on March 4th, 1915.

[14] Macnab. "Explosives," Inst. of Chem. Lecture, 1914.

[15] Miblinari.

[16] England and France were, however, more especially to the fore.

[17] Only about one tenth of the annual value of dyestuffs consumed in England is produced in England.

[18] Both azo and eosin colors were kept as secret products, but the colors were investigated by Hofmann and their mode of production published, to the great consternation of the inventors.

[19] G. T. Morgan, "Modern Dyes and Dyeing," Roy. Dublin Society, 1914. Cain and J. F. Thorpe, "The Synthetic Dyestuffs and Intermediate Products," 1913.

The production of artificial alizarin was: 1873, 100,000; 1877, 750,000; 1884, 1,350,000; 1900, 2,000,000 kilogrammes (four fifths of this was produced in Germany).

A great number of most valuable artificial dyestuffs, more or less closely related to alizarin, but not occuring in nature, have been prepared by chemists, and the total value of the alizarin-color exports of Germany at the present time is about $5,000,000.

Indigo.—This most highly prized blue dyestuff of both the ancient and the modern world was first artificially synthesized by Adolf Baeyer in 1880, but it required seventeen further years of unremitting and laborious investigation in the works of the Badische Anilin und Sodafabrik at Ludwigshafen, and the investment of nearly $5,000,000 before laboratory synthesis was translated into a commercially successful industry, for it was in 1897 that the artificial indigo was put on the market.[20]

In 1896 the world production of plantation indigo (100 per cent) was 6,000,000 kilogrammes, value $20,000,000; four fifths of this was British, obtained from 1,500,000 acres in British India. In 1904 only 500,000 acres was under cultivation, and in 1913, only 300,000 acres (see Table IV.).

TABLE IV—INDIGO

	British East Indies		Germany	
	Cwt.	Exports, Value	Imports	Exports
1896	188,337	$17,848,350	$5,180,000	$1,597,750
1899	135,187	9,901,595	2,077,250	1,961,250
1902	89,750	6,174,185	921,750	4,615,500
1905	49,525	2,782,025	300,500	6,430,250
1908	32,490	2,124,245	220,500	9,663,750
1911	16,939	1,125,000	111,500	10,457,500
1913-14	$300,000 to $350,000			

The price of indigo (100 per cent) in 1897 was $4 per kilogramme and in 1913 $1.75 per kilogramme.

By varying the ingredients in the indigo-synthesis, many very valuable dyes related to indigo have been obtained. Thus the chlorine and bromine substituted indigos are manufactured as ciba-blue, brilliant-indigo and bromo-indigo. Again with sulphur instead of oxygen, thio-indigo-red, and thio-indigo-scarlet are obtained. Moreover, by using the anthracene-grouping in the indigo-syntheses a number of most important colors have been obtained, e. g., indanthrenes, of extraordinary fastness to light; alizarin-indigo; algol-colors (Rob. E. Schmidt), in all varieties of color, and of the greatest fastness to light. The discovery of these valuable dyestuffs provoked zealous emulation on the part of the azo-color chemists, who responded by placing some very excellent new products on the market under the name of benzolight colors.

Antique or Tyrian purple was perhaps the most highly prized of all colors in the ancient world. We know from Pliny that this dye was obtained from a rather rare snail living in the Mediterranean, and which he describes under the name of "purpurea." Paul Freidländer, of Darmstadt, succeeded in 1909 in extracting this color from certain glands of two different species of snail—*murex brandaris* and *murex trunculus*—which appeared to correspond to Pliny's description of "purpurea." He removed these glands from 12,000 individual snails, developed the color by a short exposure to sunlight, extracted it with suitable solvents and recrystallized it from quinoline. In this manner he obtained only 1½ gramme of the coloring matter, so that its extreme costliness, which Freidländer estimates at about $10,000 a kilogramme, is not surprising.

On investigating the chemical nature of this color he found that it was identical with the already known synthetical compound 6.6′-dibromindigo.

Drugs and Perfumes.—Not less remarkable are the achievements of organic synthesis in connection with pharmaceutical and perfumery products.

The production of artificial drugs and perfumes is in general only a branch of the artificial color industry, for in many cases the raw materials are the same, while the methods of investigation and synthesis are, of course, identical. But whereas the artificial color industry started in England, that of artificial drugs is entirely of German origin, and may be said to begin with the discovery by Liebig of chloroform in 1831, and of chloral hydrate in 1832. It was in 1869 that the chemical works of Schering, on the suggestion of A. Liebreich, produced chloral hydrate as a commercial article.

In 1887 began the discovery of artificial antipyretic drugs, the rivals of the natural quinine. The first of these was antifebrin, the properties of which were discovered accidentally in consequence of a mistake. A specimen of acetanilide in a Strassburg pharmacy was erroneoselysupposed to,u be naphthalene and was served out na u h for some pharmacological experiments by Kahsansd Hepp. On being taken, internally, its antifebrile effect was observed. Fortunately there was enough left for analysis, and it was found that the supposed naphthalene was the long known acetanilide, which soon acquired a great vogue for this purpose. About the same time antipyrin was discovered by Knoor, who erroneously thought that it was chemically related to quinine, and that it would, therefore, not improbably possess antifebrile properties. Direct experiment showed that it did actually possess these properties in a high degree, but subsequent research showed that it was in no way chemically related to quinine. These and numerous other artificial antipyretics have been a great source of income to their inventors in consequence of the continued prevalence of influenza during the past quarter of a century.

During the period that antipyrin was protected by patent it was sold at $30 per kilogramme, while on the expiration of the patent the price was reduced to $5 per kilogramme, which still allows a good margin of profit.

These discoveries have led to the systematic study by direct experiment on animals and human beings of innumerable chemical compounds with a view of ascertaining their physiological properties. The enormous amount of most laborious work which has been carried out in connection with synthetic drugs may be gathered from the fact that up to 1912 about 5,000 artificial products had been found to possess therapeutical value of one kind or another, but, of course, comparatively few of these have permanently established themselves in medical practice. Time does not permit me to do more than refer briefly to some of the simpler and better known synthetic drugs.

Thus of antipyretics, which have or have had some considerable vogue, are: Antipyrin; tolypyrin (dimethyltolylpyrazolone); salipyrin (antipyrin-aslicylate); antipyrin mandelate (tussol, for whooping cough); neopyrin; pyramidon (three times as strong as antipyrin)-dimethylamino-antipyrin); antifebrin; phenacetin (cheapest antipyrin excepting antifebrin, about $1.50 per kilogramme, and less poisonous than antifebrin); lactophenin, lactyl-p-phenetidine; aminophenacetin or phenocoll (also has an antiseptic action).

The above series derived from aniline affords a good illustration of the dependence of physiological properties on chemical constitution. Aniline itself is a powerful antipyretic, but is extremely poisonous, owing to its ready absorption and action on haemoglobin. By introducing the acetyl group the toxic properties are much reduced owing to its greater stability, although acetanilide is slowly hydrolyzed with liberation of analine, so that after a time the symptoms of aniline poisoning may supervene. The observation that acetanilide is partially oxidized in the system to *p*-aminophenol led to derivatives of the latter being tried. Thus phenacetin has been found to possess powerful antipyretics and greatly reduced toxic effects.[21]

Hypnotics.—Sulphonal was accidentally discovered to possess hypnotic properties in connection with experiments on the transformations of sulphur compounds in the animal system. A dog, which had been dosed with the newly discovered sulphonal, in Baumann's laboratory at Freiburg, i.B., was found to fall into a deep sleep.

More powerful hypnotics were found to result from introducing further ethyl groups:

$(CH_3)_2C(SO_2.C_2H_5)_2$. Sulphonal

$(CH_3)(C_2H_5)C(SO_2.(C_2H_5)_2$ Trional

$(C_2H_5)_2C(SO_2.C_2H_5)_2$ Tetronal.

In connection with the manufacture of sulphonal, I may refer to an interesting difficulty which was experienced by the Elberfeld Color Works owing to the appalling smell of the mercaptan from which it is prepared, and of which Emil Fischer and Penzoldt have shown that the human nose is still capable of appreciating 1/400,000,000 milligramme. In spite of this, German thoroughness has been successful in so perfecting the apparatus in which the manufacture is carried on that no nuisance is occasioned.

Veronal (diethylbarbiturie acid) (E. Fischer and Mering, patented by Merck in 1903) is one of the most widely used hypnotics. Although it was formerly supposed to be practically free from toxic properties, in recent years cases of veronal poisoning have been known to occur.

Antineuralgics.—Salicylic acid, one of the first drugs to be artificially prepared (Kolbe, 1860), acetyl-salicylic acid (aspirin), and salol (phenylsalicylate), though extremely simple synthetic products, are almost exclusively made in Germany, with the result that their price has now greatly increased. Even synthetic phenol which is necessary for the above preparations, was exclusively made in Germany and kept down the price of coal-tar phenol. The price of phenol has now enormously increased from 7 cents per pound to 33 cents per pound, and is likely to go higher. (*Pharm. Journal*, 1915).

Anti-gout drugs (Uric acid solvents).—Piperazine (discovered by Hofmann in 1890), lysidine, urotropine (hexamethylene tetramine), atophane (*a*-phenylcinchonic acid).

Suprarenine.—This is of special interest. The active principle of the suprarenal glands known as adrenaline[22] had for some years been found to be of great value for increasing the blood-pressure, contracting the blood-vessels, and arresting haemorrhage. It requires the suprarenal glands of 40,000 oxen to prepare 1 kilogramme of adrenaline, but this substance has been artificially synthesized by F. Stolz, and is put on the market as suprarenine by the Höchst Color Works. The syntheses of adrenaline may be presented thus:

Catechol → Chloraceto-catechol ($CH_2ClCOCl$) → Methly-amino-sceto-catechol (CH_2NH_2) → Adrenaline

Al-amalgam

Natural adrenaline[a] is laevo-rotatory; the synthetic can be resolved by tartrate; the laevo is fifteen times as potent as the dextro.

The German color manufacturers are organized into two principal groups or trusts (Interessengemeinschaften). (1) Badische Company, of Ludwigshafen; Bayer Company, of Elberfeld; Berlin Aniline Company. (2) Cassella Company, of Frankfurt; Meister, Lucius, und Brüning, of Höchst.[23]

The share-capital of the above two gropus in 1911 was $40,000,000 paying a dividend of 25.8 per cent, and probably now about $60,000,000, dividend 28 per cent.

In 1860-70 Germany imported about $12,500,000 worth of dyes per year, while in 1912, Germany exported about $50,000,000 and produced about $62,500,000 of dyes.

The composition of the personnel who carry on these German color works is at the bottom of their success. Take the works of Messrs. Meister, Lucius, und Brüning as an example. In 1913 the composition was as follows: Workmen, 7,680; managers, 374; expert chemists, 307; technologists, 74; commercial staff, 611. Contrast with the above the fact that the six English factories now producing dyestuffs employ altogether only thirty-five chemists, while evidence of their relative activities is again furnished by the circumstance that between 1886 and 1900 the English firms took out only eighty-six patents, whereas the six principal German firms were responsible for 948 during the same period.

Having shown that these German coal-tar color manufacturers are without rivals from the commercial point of view, I feel it to be my duty to point out also that their industry is carried on under conditions of labor which are highly creditable to the management.

Purchasing Coal on Heat Unit Basis

It is inevitable that large users of coal will insist more and more upon contracting for their fuel supplies on some basis other than that of a set price per ton. In spite of certain objectionable features and some opposition, which is not without cause for its existence, there is evidence of a steady increase in the use of what is generally termed the "heat-unit basis" for the purchase of coal. A simple illustration may serve as an explanation of this tendency: Three Illinois State institutions with substantially the same shipping rate received bids on coal supplies from dealers A, B and C, their respective prices being $1.45, $1.72 and $1.43 per ton. Now, as subsequently proved to be the case, A was able to deliver, and did deliver, coal with an ash and moisture content of 21 per cent and a heat-unit value which entitled him to a settlement price under the contract of $1.55 per ton. The deliveries by B, contained an ash and moisture total of 30 per cent and a heat-unit value which resulted in a settlement price of $1.12 per ton. Similarly, C with a total ash and moisture content of 33 per cent was entitled to a settlement price of $0.97.

It is seen that dealers A and C estimated their coals at substantially the same price, say $1.45 per ton. The intrinsic values, however, which are at least relatively indicated by the settlement price, are shown to have a difference of substantially 60 cents per ton. Similarly, dealer B, who estimated his coal as worth $1.72 per ton finds its actual value, or at least its settlement value according to the terms of the contract, to be $1.12 or 60 cents less per ton. The figures show also that a dealer may name his price per ton with very little knowledge as to the intrinsic value of the material. There is little if any relation between the price asked and the actual heat value to be delivered. Illustrations of such discrepancies could be multiplied indefinitely.—Bulletin 29, Illinois State Geological Survey.

[20] Baeyer's first patent for the synthesis of indigo from o-nitrocinnamin acid was taken out in 1880, and by 1907 there had been no less than 316 patents obtained in Germany for processes connected with the preparation of indigo.

[21] Chemistry of Synthetic Drugs, P, May, 1911.

[22] Discovered by Takamine in 1901.

[23] "German Coal Tar Companies," *Textile Mercury*, January 9th, 1915.

Forging Shrapnel Shells*

Some Details of Modern Methods Now in Use

By Douglas T. Hamilton

WITHIN the last few months, many methods have been suggested for making shrapnel forgings, but a comparatively small number have been put into use. Practically speaking, no two governments have adopted the same method. The Russian government uses double-acting horizontal hydraulic forging presses in which two operations are performed at the same time on different forgings. For instance, while the punch in one end of the machine is piercing a heated billet, the ram on the return stroke performs the hot drawing operation on another shell located at the opposite end of the machine. In this way a shell is completed at each cycle of the machine—forward and return stroke. The French government, up to a short time ago, used steam hammers for this purpose, and produced shrapnel forgings in practically the same manner as a drop-forging is made, the punch being carried in the ram of the press and the die held on the bed. This is rather a slow process and requires more than one heating to complete the forging. The German government uses a horizontal hydraulic forging press for piercing the billet and a steam-driven machine for drawing the forging, which receives its motion from a rack and pinion. This method has the advantage over the hydraulic press of being more economical in the consumption of power.

The practice followed by different concerns in this country and Canada, at the present time, differs to a large extent. Some manufacturers are using a method that dates back as far as 1890. Others are using a more improved method developed about 1895, whereas about three concerns are using a still more improved method developed in the last three months.

The first method (known as the Caley process) of making shrapnel forgings in this country had its inception about 1890 and was used almost exclusively until 1895. This comprised a slug-forming and billet-piercing operation followed by a successive reduction and elongation of the forging through drawing dies. The order of these operations is shown diagrammatically in Fig. 1. The information given herewith pertains to the making of a forging for a 3-inch shrapnel shell. As shown at *D*, a billet of steel 3¼ inches in diameter and 6½ inches long was cut off from a bar with a cold saw, and formed into a cone shape under a vertical hydraulic press having a capacity of 100 tons. The billet was heated in a furnace to about 1,900 deg. Fahr., dropped into the impression in the die and forced into shape by a hydraulic plunger having a depression in the lower end which centered the blank. The result of this operation is shown at *F*.

The next step was to anneal the billet, after which it was pierced as shown at *C*, and at the same time slightly elongated. This operation was handled in a hydraulic press. On a 0.70 per cent carbon steel billet the pressure on the punch in the piercing operation was 20,000 pounds per square inch and the machine used was a vertical hydraulic forging press of the type referred to having a capacity of 100 tons. From the piercing operation the forging was taken direct without annealing to the horizontal hydraulic draw press, and as is shown at *H* was located on a punch and forced through a series of drawing dies which gradually reduced the shell to the correct diameter, 3⅛ inches, and drew it out to the required length, about 8¾ inches.

A point worthy of attention is the preparation of the cone-shaped billet. The smallest end was made slightly smaller than the smallest reduction die in the series. The reason for this was that if any drawing were done on the end of the shell the front corner would be drawn over and deformed, increasing the amount of machining required. The drawing dies in this case were six in number, as shown at *H*, and were reduced on a sliding scale of the following proportional reductions. First, 0.100 inch; second, 0.080 inch; third, 0.060 inch; fourth, 0.040 inch; fifth, 0.030 inch; and sixth, 0.020 inch. This gave dies of the following sizes, in inches, starting with the largest in the series: 3.355, 3.275, 3.215, 3.175, 3.145, and 3.125.

The drawing punch was lubricated occasionally with graphite. After drawing, the forging is annealed to obtain the proper physical qualities. This method of making forgings for a 3-inch shrapnel shell is capable of producing 400 in ten hours.

About 1895 the following method, known as the Hollinger process of making shrapnel forgings, was devised. Instead of making the billet conical in shape before piercing, this preliminary operation was dispensed with, and to facilitate the work, as well as to reduce the friction of the flowing metal, the arrangement of the piercing punch and die was changed. This process is shown in Fig. 2, and was accomplished in a hydraulic press provided with two cylinders, one located at the bottom and the other at the top of the press.

The operation was as follows: The die *a* was held in a movable frame *b* and the piston *c* acted first. The first position after the billet was dropped into the die is shown at *B*. Here the die *a* and punch *d* remained stationary while the piston *c* descended, pushing the billet through the die and over the punch. When the piston reached the end of its stroke, as shown at *C*, the lower cylinder began to act and the frame carrying the die was raised. This frame, as shown at *D*, carried a stripper plate *e* which removed the pierced billet from the punch and located it so that it could be picked off with a pair of tongs. A subsequent operation of hot-drawing as shown at *E* was required, which is similar to that described in the first method. The method just described was used chiefly for 6- and 8-inch shrapnel and projectile forgings, and at the present time is still used for 3- and 6-inch shell forgings. It requires much less power and turns out a better and more concentric forging than the method previously described. The production on 8-inch shells is about 180 in ten hours, and 250 on the 3-inch shell.

The increased demand for shrapnel within the last few months has been instrumental in bringing about a radical improvement in the production of forged shells. Previously, the aim was to get the internal diameter as close as possible to the finished size and to do comparatively little machining on it; in fact, this is still, in a great number of cases, one of the requirements. While at first glance this would appear to be the logical way of handling the work, on further investigation it is found that the forging of the shell to the comparatively correct size is much more expensive than to leave sufficient metal to machine all over. In the first place, a hydraulic machine of 100 tons capacity costs considerably more in initial outlay than a turret lathe, and in

* Reproduced by courtesy of *Machinery*.

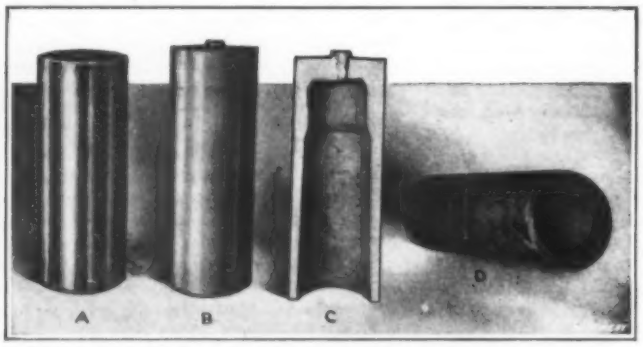


Fig. 4.—Examples of shrapnel forgings turned out on a power forging machine.

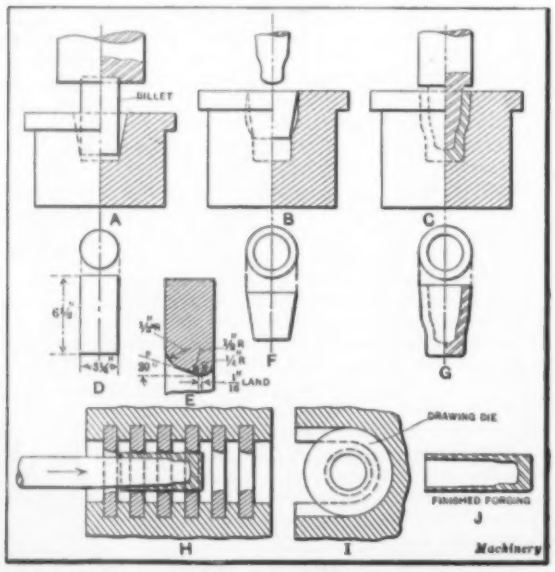


Fig. 1.—Diagram illustrating Caley process of making shrapnel forgings in hydraulic forging presses.

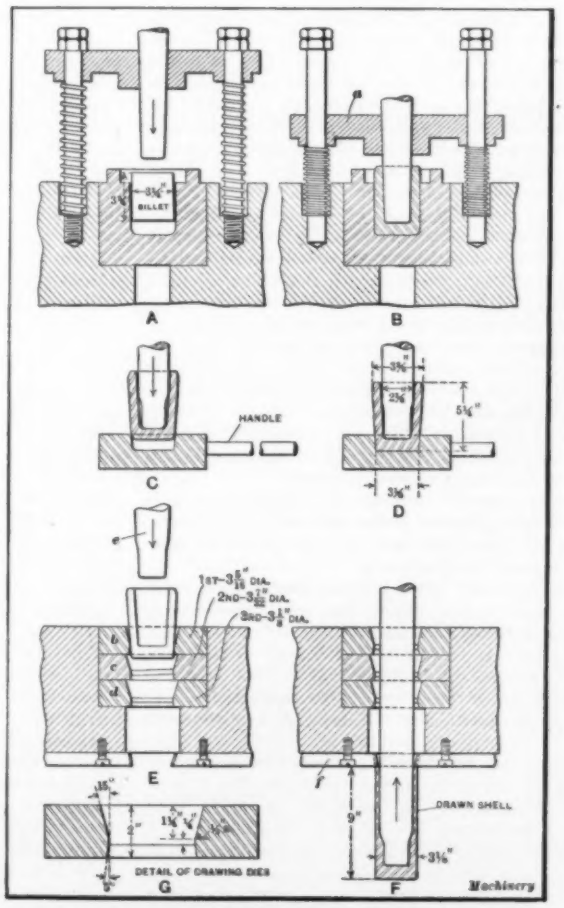


Fig. 5.—Diagram illustrating method of piercing and drawing shrapnel forgings in a power press.

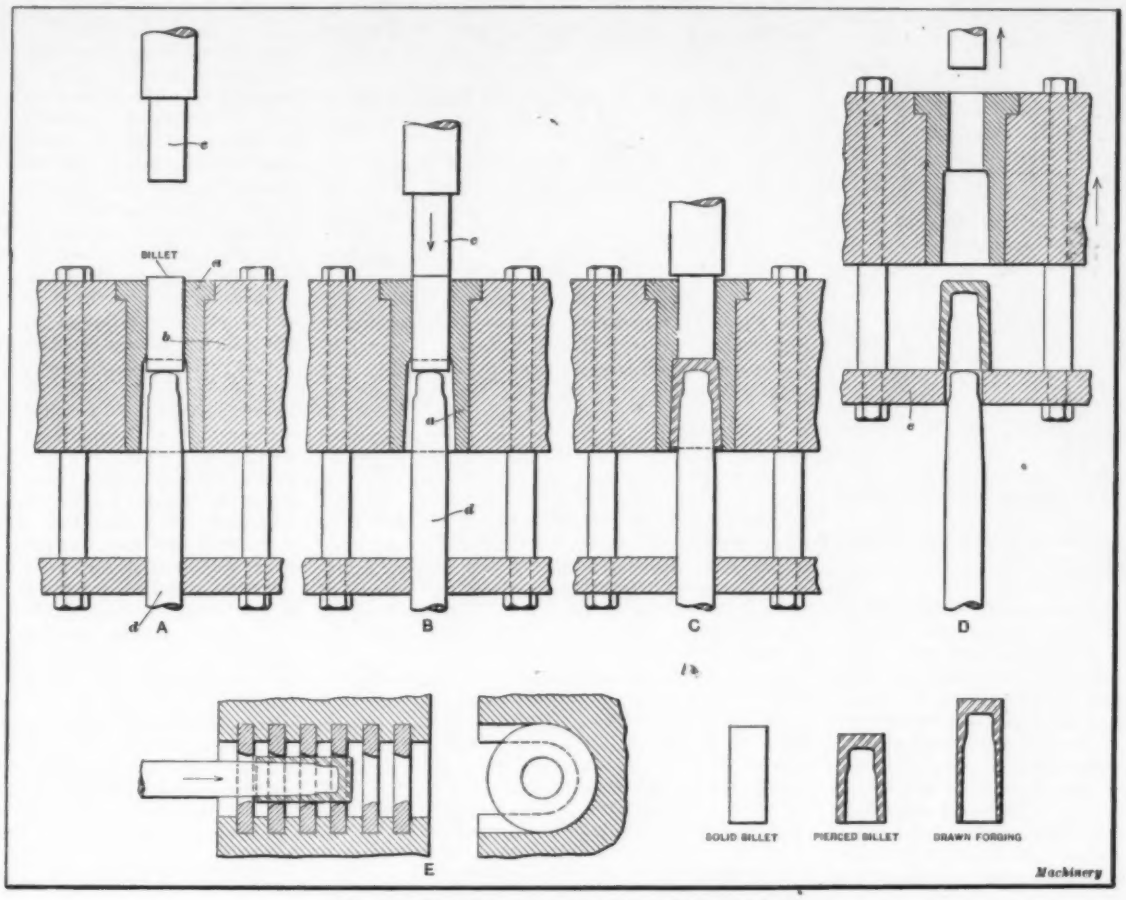


Fig. 2.—Hollinger process of making shrapnel forgings.

the second place it is more expensive to operate. The cheapest method of making a shrapnel forging is to rough-forge it to approximately the correct shape and then finish to exact shape and diameter in turret lathes or semi-automatic chucking machines. This simplifies the forging process and also decreases the production costs.

One of the later methods of making shrapnel forgings is shown diagrammatically in Fig. 3. A billet of steel 6½ inches long by 3$\frac{7}{16}$ inches diameter is heated to a temperature of from 1,900 to 2,100 deg. Fahr., and then dropped into the impression in the die *a* held in a special cast-steel die-holder *b*. To do this, die *a* is drawn out from beneath the punch, punch guide *c* removed and the billet dropped in. Then the guide is replaced and the die-holder slid in until it contacts with the stop *d*. The press is now operated, and as shown at *B*, advances, piercing the billet and making the metal flow up around the walls of the punch.

The punch now retreats, carrying the centralizing guide *c* with it. The die-holder is now drawn out from under the punch onto a bracket projecting from the bed of the press. The high-carbon steel, hardened block *e* then drops out of the die, as is also the case with the finished forging. This block *e*, of course, is heated up to a considerable extent due to the hot metal resting on it so that several blocks of this kind are provided. In the illustration, as shown at *C*, centralizing guide *c* is shown attached to the punch. In actual operation this is not the case. When the punch rises, guide *c* is stripped from it by the stripper plate *f* so that the guide is gripped with a pair of tongs and laid down on the bed of the press until a fresh heated billet has been placed in the die impression ready for the next piercing. The punch is made from special hot punching steel and the die from chilled cast iron. The production of forgings by this method for a 3-inch shrapnel shell is about 600 in ten hours.

The amount of metal left for machining by this method varies from $\frac{1}{8}$ to $\frac{3}{32}$ inch on the internal and external diameters. The forging after annealing is then machined inside and out on turret lathes, or semi-automatic chucking machines. The accepted method is to first machine the internal diameter and then hold the shell on an expanding arbor and machine it on the external diameter.

One of the latest developments in the art of producing forgings for shrapnel shells is the adaptation of the power forging machine to this work. As has been previously mentioned, there are several methods of producing shrapnel shells, and as it has been conclusively proved that the forged shell is superior to the shell made from bar stock, it is only natural that several methods for making the forgings would be developed. In the forging machine method, a bar slightly larger than the finished diameter of the forging is cut off, making a billet about 5½ inches long. This billet, for a 3-inch shell, weighs about 9¼ to 9½ pounds.

The billet is heated to a white heat in a furnace, the temperature being about 2,000 deg. Fahr., depending on the carbon content and other constituents in the steel, and is then placed in the lower impression of the forging die. The machine used for this size of forging is a standard upsetting and forging machine provided with a special crankshaft. Upon being operated, the lower plunger, which is larger than the diameter of the powder pocket in the shell, advances and pierces the billet. The pierced billet is then raised to the next impression, and the machine again operated. The second punch is longer than the first and smaller in diameter. The billet is forced up on this punch, which reduces it in diameter and increases its length. After the second impression the partially formed shell is then placed in the third or final die impression, where it is given two blows, being given one half turn after the first blow to form it more perfectly. The operations just enumerated are performed with only one heating of the billet, and the production of a 3-inch shell ranges from 400 to 450 perfectly formed rough forgings in ten hours.

The dies for this work are, of course, constructed upon a somewhat different principle from the ordinary forging die, because in this case it is necessary to make the metal flow upon the punches. The dies, therefore, are so constructed that they recede as the punch advances, which tends to make the metal flow up on the punch. The practicability of this method is well illustrated by the samples shown in Fig. 4. Here *D* is the rough forging just as it comes from the machine, with the exception that the mouth has been trimmed. *C* is a section of a shell made from low-carbon steel about 0.30 per cent carbon; *B* is a shell made from 0.50 per cent carbon, 3½ per cent nickel steel. This has been rough-turned, as the illustration shows. The homogeneity of the forgings is clearly indicated. *A* is a forging made from low-carbon steel, finish-turned.

One of the most interesting points about this method is its cost as compared with shells made from bar stock. To produce a 3-inch shell from bar stock requires about 22 pounds of material, and on metal costing 10 cents per pound, a bar shell—exclusive of machining—costs $2.20; to produce the same shell on a power forging machine requires about 9¼ to 9½ pounds, and figuring on 10 cents per pound the cost for material is only $1—a saving of $1.20 on each shell. Furthermore, the production of shells from bar stock on automatic machines is about twelve to fifteen per day. The number of forgings that can be turned out in the same time is 400 to 450, and the number that can be machined in this time varies from forty to fifty for two operations. It is therefore evident that the production of shells by forging is far superior to the bar method, and the forged shell is more satisfactory from every standpoint.

Another interesting development in the forging line is shown diagrammatically in Fig. 5. This method comprises three operations, and is handled in a No. 80½ Bliss press capable of exerting a pressure of 1,200 tons. A billet 3¼ inches in diameter by 3¾ inches long is

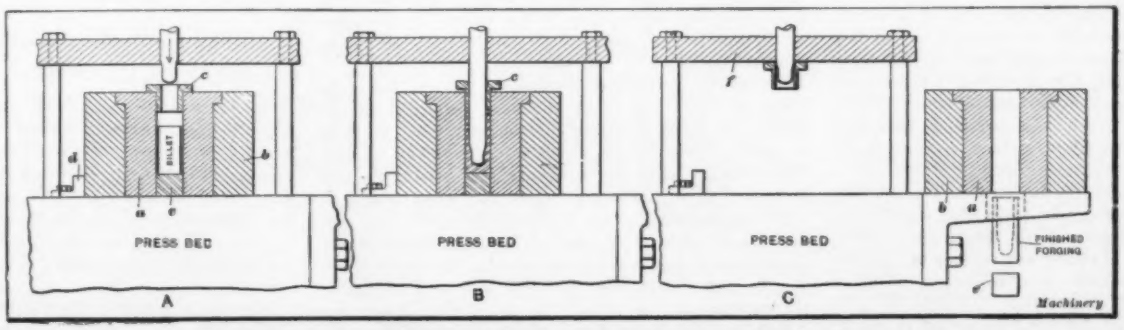


Fig. 3.—Improved method of making shrapnel forgings in one heat and operation.

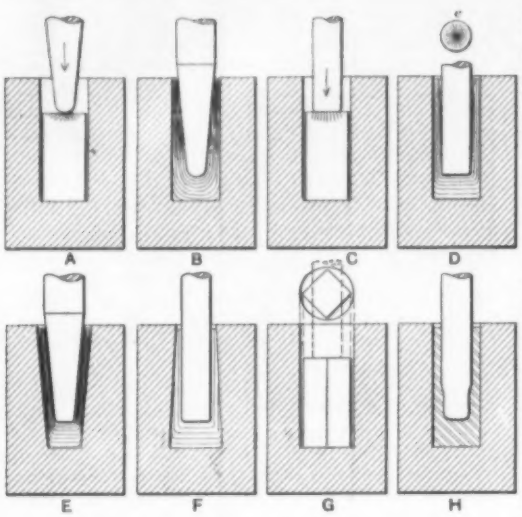


Fig. 6.—Diagram illustrating flow of hot metal while being pierced.

heated in a furnace to 1,976 deg. Fahr. and then quickly placed in the die shown at *A*. The press is operated, and the punch in descending pierces the billet, being guided by the guide *a*, as shown at *B*, which also acts as a stripper. The forging retains its heat to a certain extent after this operation, the temperature being about 1,380 to 1,425 deg. Fahr. This is sufficient to perform the second minor operation which, as shown at *C* and *D*, consists in forcing the heated billet into the die-block to reduce the diameter of the lower end and facilitate the succeeding operation. This reducing operation is performed with the same type of punch as is used in the succeeding operation, and the die-block is simply laid on the top of a bolster while the reducing is being done.

The final forming or drawing of the forging is accomplished as shown at *E* and *F*, the same type of press, being used for this purpose.

In the manufacture of shrapnel shell forgings, the first operation is that of piercing, and to accomplish this satisfactorily, it is necessary to understand the action of a piercing punch on a semi-plastic billet of steel. There are certain fundamental laws governing the flow of metals under pressure and a study of these is of exceptional interest. An attempt has been made in Fig. 6 to illustrate diagrammatically some of the principles involved, and in the following discussion it should be understood that the billet is made from 50-point carbon, 70-point manganese steel, 6½ by 3⅞ inches in diameter.

At *A* a round-end tapered punch is shown in contact with the heated billet, and the lines show the possible flow of the metal, i. e., the material commences to "pack" at the end of the punch. In this case the walls of the die are straight. At *B* the billet is being pierced, and the resultant effect on the flow of the metal is indicated. Here it will be seen that the pressure increases as the punch descends, because of the wedging action on the metal and the friction between the surfaces of the sides of the punch and die. The pressure on the end of a punch of this shape is about 20,000 pounds per square inch.

By leaving the sides of the die of the same shape as at *B*, but making the end of the punch square instead of round and not tapered, different action is caused. When the flat punch, as shown at *C*, first contacts with the metal, the pressure required is greater than at *A*, but as soon as the metal commences to flow as at *D*, the pressure decreases. For instance, suppose the pressure required at *B* to pierce the billet was 100 tons; on the same material at *D* the required pressure would be only 70 tons—a decrease of 30 per cent. The metal, however, does not follow the sides of the punch as closely at *D* as at *B*, and this accounts in part for the reduction of power required. The action of hot flowing metal on the face of a square punch is just the reverse of what would naturally be expected. Instead of the punch wearing away at the edge, the center first shows signs of wear as indicated at *c*. Seams are opened up in a radial direction caused by the hot metal attacking the softest parts in the face of the punch.

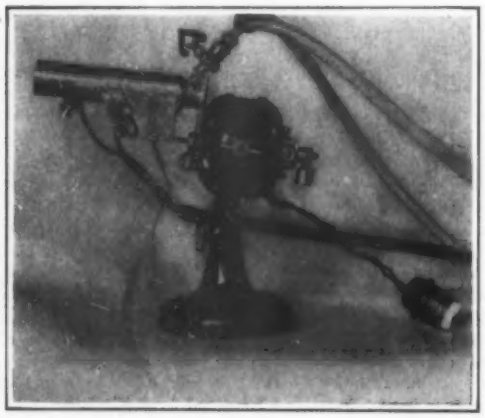
Again, a different condition exists to that shown at *B* and *D*, when both the die and the punch are tapered as shown at *E*. Here the friction of the extruded metal on the walls of the die and sides of the punch is excessive, and it is practically impossible to produce a satisfactorily pierced billet in this manner. From a theoretical standpoint, the conditions shown at *F* are ideal. Here the sides of the punch are straight, the end flat, and the walls of the die taper or increase in diameter toward the bottom. In this case the friction of the flowing metal is greatly reduced because of the lessening of the wedging action. Other considerations, however, make this method impracticable.

A still greater reduction in the pressure necessary to pierce a billet is shown at *G*. Here a square billet instead of a round one is being pierced. In the plan view it will be noticed that the friction on the walls of the die is greatly reduced, and the pressure continues low until the extruded billet contacts all around with the surface of the die. The completed product, however, is inferior to that made from a round billet. From the previous remarks it will be seen that a punch and die that would best meet the requirements is one having a rounded end as at *B*, straight sides as at *D*, and straight walls in the die. The most satisfactory punch and die for piercing shrapnel forgings when all the variable conditions are considered would be as shown at *H*.

Plating by Impact

An account has been published of a metal spray process of plating, the invention of a Swedish engineer, and from a patent recently issued it appears that a similar process has been in course of development by Mr. C. Francis Jenkins of Washington, D. C., better known as the inventor of the now standard type of motion-picture projecting machine.

This process can perhaps be best understood if one remembers that when an electric lamp bulb gives way a discoloration of the inside of the bulb occurs; and also that when a fuse plug "blows" the mica cover is discolored. This color is black when the fuse is of lead, but it is a reddish color when a piece of copper wire is used. This would seem to indicate some kind of a deposit resulting from the blowing of the fuse, that it is not completely volatilized. Under a magnification of 300 diameters, or more, minute particles of a copper wire are discovered, adhering to the cover of the fuse plug, and when a common visiting card is used for a cover instead of the mica, a decided deposit is attained. Repeated charges of such a fuse result in a complete coating on the card. When this surface is burnished with some smooth, hard object, a shiny, polished metal surface results.



Early experimental apparatus using electric fan motor to operate the feed rolls.

A fuse used in this manner is in effect a gun which throws out a shower of miniature shot so small as to be invisible to the naked eye, and this would operate successfully for covering almost any surface but for the annoyance of the frequent replacements with short pieces of copper wire.

This led naturally to the development of a special "gun" into the barrel of which a copper wire is continuously fed. A pair of small rollers actuated by a motor pulls the wire off the supply spool and projects it across the barrel until the end touches the opposite surface. The inner lining of the barrel and the propelling rollers are in series in an electric circuit, though insulated from each other, so that a short circuit is formed between the rollers and the lining, and the wire is instantly melted, and the heat of the wire causes it to be thrown out of the barrel against any object held in position for that purpose. When a plurality of wires are used, or a flat ribbon, in order to cover a larger area in a given time, it is found desirable to add a propelling force, and this is done by introducing into the barrel behind the wire a small charge of explosive gas, i. e., oxy-hydrogen gas, gasoline vapor, ether, or common city gas properly mixed with air will answer. The melting of the wire explodes the charge which projects the miniature metallic particles, that are momentarily suspended in the gas, against the object to be coated. As the wire is steadily fed across the barrel, and the melting is instantaneous, there are time intervals during which new charges of gas are introduced following successive ignitions, and a succession of miniature explosions following each other with rapid frequency, something like the exhaust of an automobile motor.

It has been found that objects of a great variety can be coated in this manner and that any electrically conductive material can be used for the purpose. Coatings of lead, tin, zinc, aluminium, iron, copper, silver, and gold are readily formed in this manner. The different melting points of the different metals is taken care of by means of an adjustable rheostat in the melting circuit. A coil is better than a grid, for reasons not necessary here to explain.

Wood, metals, fabrics, plaster, wax, glass, in fact almost any substance, can be successfully coated. Metallic platings of one's thumb can be taken in this manner, for it seems that the metallic particles, being so very, very small, give up what heat they carry so quickly that no unpleasant sensation results. With wax or glue casts one can produce a shell of extreme thinness by melting out the glue in hot water. In like manner ribbons of extreme thinness can be made as a continuous process.

One of the meritorious features of this method is its great economy, for all of the heat developed in the melting of wire is usefully employed; none of it is wasted. Articles which would be destroyed in an acid electroplating bath can be coated, and coating by this process is many times more rapid than electroplating.

The accompanying line drawing illustrates the general construction of the gun, *B* being the stock, *A* the barrel, lined with mica, as shown by the heavy black line *D*, with a conductive lining *E* electrically connected through one of the wires *I* to the source of current. Another of the wires *I* is electrically attached to the gun barrel and the wire-propelling rollers *H*. The third of the wires *I* goes to the latch *S*, which is an electric switch controlling the motor (not shown) which actuated the rollers *H* through a flexible shaft. *G* is the wire to be volatilized, and *J* is a tube which leads explosive gas into the barrel of the gun. A small ball in the enlargement of the tube *J* near the upper end serves as a check valve, preventing "backfire" down the tube.

The operation of the gun is perhaps almost obvious from the drawing, the wire *G* being fed forward by the rotation of the rollers *H*, soon comes into contact with the inner lining *E* of the gun barrel and thereupon is instantaneously melted. The melting of the wire explodes the gas which has meantime entered the gun barrel through the tube *J* and the minute globules into which the metal forms immediately it is melted are projected with violence against whatever is set in front of it, and stick thereto. Subsequent charges of these minute pellets, so small as to be invisible to the unaided eye, strike on the same spot, forming a permanent weld with the preceding charges until a homogeneous coat of any thickness desired results.

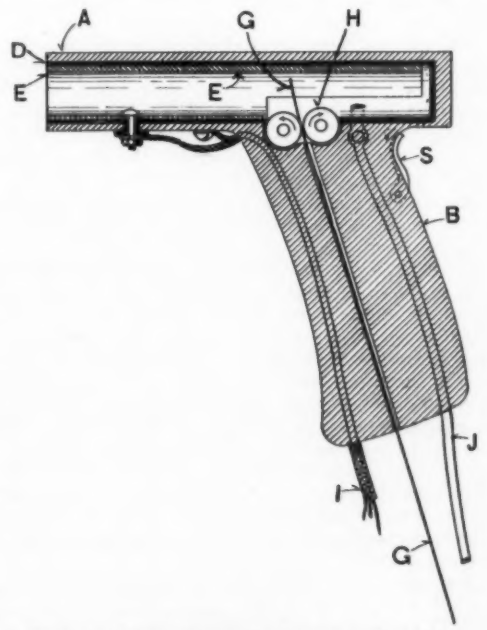


Diagram illustrating general construction of the gun.

Tin, says a writer in the *Bulletin* of the Imperial Institute, has always been to a large extent a British product.

The Largest American Gas Engine

THE largest single tandem gas blowing engine ever constructed in the United States was on exhibition recently at the works of the Mesta Machine Company, West Homestead, Pa. The gas cylinders are 46 inches in diameter, the air cylinder 84 inches in diameter with a common stroke of 60 inches. The engine will run at a speed of from 45 to 85 revolutions per minute, depending upon operating conditions. The accompanying illustrations show the gas engine on the erecting floor of the Mesta Machine Company and gives a good idea of how the engine will appear when finally erected at the plant of the Pennsylvania Steel Company, Steelton, Pa., where it is to be employed, because the platform in the foreground is approximately at floor level relative to the engine.

When gas-blowing engines were first introduced in the United States many objections were voiced on account of the great number of moving parts, but the view of this big machine, which show the valve operating side, proves that this objection is no longer valid.

The air end is equipped with Mesta automatic plate valves, which require no valve gearing. The use of these valves has made possible the placing of the air cylinder in tandem with the gas cylinders so that the air cylinder piston can be directly driven through an extension of the gas cylinder piston rod. This arrangement noted is much simpler than that of placing the air cylinder on the opposite end of the bed plate to the gas cylinders, which method has been so generally used in the design of gas-blowing engines in the United States.

The engine is of the center crank type. A double bearing bed plate is used with this crank and results in an equal distribution of the stresses.

At the present time a duplicate unit is being built, and more complete information, with test results, will be available as soon as the engine is put in operation.

Death of Pierre-Emile Martin

PIERRE-EMILE MARTIN, the inventor of the open hearth process of making steel, died on May 23, in his ninety-first year. He was born at Bruges, August 18, 1824.

It was only recently that the Iron and Steel Institute, England, had awarded to Martin the Bessemer Medal in recognition of his services in the manufacture of steel; and the statements made by Dr. Arthur Cooper, acting as president of the Institute in making the presentation, which was through a representative of the French Embassy, tell very clearly the history of the developments accomplished by Martin, as follows:

"Pierre-Emile Martin (Fourchambault, France), the recipient of the Bessemer Gold Medal of the Iron and Steel Institute, is one of the last of the pioneers connected with the great development in the manufacture of steel which took place in the latter half of the nineteenth century. He is the inventor of the process for the manufacture on a practical scale of open-hearth steel, for which his first patent was taken out in July, 1865. The process, which consists of melting pig-iron with scrap steel and iron oxide, has ever since been known on the Continent as the Martin process, but in this country it is commonly called the 'open-hearth process.' The actual discovery that steel could be made in this way was not new. Réaumur, in 1722, had already produced steel by melting a mixture of pig-iron together with scrap and iron oxide, but his experiments had never gone beyond the laboratory stage. Many metallurgists subsequently endeavored to follow the method indicated by Réaumur, but the difficulty of obtaining a sufficiently high temperature in the melting hearth proved an obstacle which none of them could overcome.

"The invention of the regenerating furnace by Sir William Siemens at length overcame this difficulty, and in the early sixties Pierre Martin began experiments at Sireull, in France, with a Siemens furnace of 1 ton capacity. After many trials and disappointments he at length succeeded in producing open-hearth steel of regular quality and composition, and the process was taken up by two of the leading French steel works. The success of the new process naturally aroused the attention of Martin's competitors, and it was not long before the validity of his patent rights was attacked on the strength of Réaumur's prior publication of the results obtained 123 years earlier, although these had led to no practical result. Martin, not having the means to defend the lawsuits brought against him, was compelled after two or three years to give up the struggle against his opponents and to retire into private life. For many years his existence was forgotten, although the process had always continued to be associated with his name. When it became known a few years ago, through the Comite des Forges de France, that Mr. Martin was still alive, steps were immediately taken to recognize his claim to the merit of the invention which had been denied to him in earlier years, and at a banquet held in Paris in June, 1910, the steel-makers of Europe united to do him honor, and he was created by the French Government an Officer of the Legion of Honor.

"By the time Martin had perfected his method, the Bessemer steel-making process, which had been invented eight years earlier, already completely held the field, and the Martin process, especially on account of its higher cost, was unable for many years to make much headway against its powerful rival. The introduction in 1879 of the basic-lined furnace of Thomas and Gilchrist, by which phosphoric iron became available for conversion into steel, gave a great impetus to the manufacture of steel in the open-hearth, and the production of open-hearth steel (Martin steel) began from that time to increase steadily. In point of quantity it has now far out-distanced that produced by the Bessemer process, the world's production of steel for 1913 having been 74 million tons, of which 44 millions were made by the Martin process and 30 millions by the Bessemer process."

Light-Stroke*

THERE is an Italian proverb, "All diseases come in the dark and get cured in the sun." Interpreted from the standpoint of modern bacteriology and sanitary science, this statement has something to commend it, for light is to-day recognized as a potent defense against pathogenic micro-organisms by virtue of the destructive action which it exerts on them. Light, however, unquestionably has pathologic as well as physiologic effects on higher organisms. Under ordinary circumstances, we are exposed to sunlight of moderate or moderated intensity for limited periods. Exposure to intense sunlight, on the other hand, is by no means an innocuous procedure. Freckles are a familiar indication of a physiologic response to light, since they make their appearance on those parts of the body which are exposed to the sun's rays. Predisposed individuals react with more pronounced cutaneous symptoms under conditions in which sunlight is believed to play a rôle as a causative agent. Indeed, the skin is not the only organ which may react.

In this connection, the phenomenon of sunstroke is at once suggested. This term is, however, subject to much confusion and misconception. Some of the symptoms attributed to it are, without question, associated with heat exhaustion induced by elevated temperatures. There is some evidence in medical literature of the possibility of what Manson has termed sun traumatism, in which the heat regulation may not be alone at fault; for precisely similar effects have not been observed after exposure to heat from such artificial sources as furnaces. In so-called sun traumatism the morbid state is characterized as a rule by sudden death occurring without a warning. The sense of distress in a hot sun is not precisely like that provoked by a hot fire. This justifies one in raising the question as to whether the sunlight as such may not produce serious pathologic consequences, particularly if the subjects have not become gradually habituated to sun exposure.

The photodynamic action of certain organic substances, to which attention has been called of late, may have a bearing on the problems raised by some of the pathologic effects of light. It has been shown that injection of suitable sensitizing compounds into albino mice (which lack skin or hair pigments to protect them against the direct action of the light rays) renders the animals peculiarly irritable when kept in the light, though they show no untoward effects in the dark. Hematoporphyrin, a derivative of the pigment of the red blood corpuscles belonging to the group of investigated photodynamic substances, is of special interest because it is actually known to arise in the animal body under pathologic conditions. The symptoms which the animals treated with hematoporphyrin develop in the light are not due to any inherent toxicity of the compound itself. They ordinarily consist of lesions of the skin, accompanied by subcutaneous edemas and other severe effects. These may assume an acute or a chronic form and are not infrequently fatal in their experimental outcome.[1] In trials on himself, Meyer-Betz[2] has actually demonstrated the photosensitizing effect of hematoporphyrin on man. The most recent progress in this field is represented by Hausmann's ability to sensitize animals with porphyrins to such a degree that profound reactions are produced immediately on exposure to light.[3] In his earlier work, to which reference has already been made, the cutaneous symptoms usually were the first manifestations of abnormality, disturbances of the central nervous system making their appearance much later, if at all. By Hausmann's new technic it is possible to render animals so responsive to the effects of light that as soon as they are exposed to the rays they promptly enter into a narcosis terminating fatally in a few minutes. By treatment with the light of a quartz lamp, suitably prepared, mice manifest the chronic forms of this sensitization. The ultraviolet light is also concerned in the change. Brief treatment with light from a quartz lamp may lead to necrosis.

This intensely acute mode of death by exposure to light has been expressively designated as light-stroke (*Lichtschlag*) by Hausmann to distinguish it from the manifestations of true heat-stroke. It offers an experimental analogy, perhaps, to the obscure harmful effects of sunlight which still await a rational scientific interpretation.

* *Journal* of the American Medical Association.

[1] Hausmann, W.: Die sensibilisierende Wirkung des Hämatoporphyrins. Biochem. Ztschr., 1910, xxx, 276; Strahlentherapie, 1913, iii, 112.

[2] Meyer-Betz: Deutsch. Arch. f. klin. Med., 1913, cxii, 476.

[3] Hausmann, W.: Ueber die sensibilisierende Wirkung der Porphyrine, Biochem. Ztschr., 1914, lxvii, 309.

Correspondence

[The editors are not responsible for statements made in the correspondence column. Anonymous communications cannot be considered, but the names of correspondents will be withheld when so desired.]

Flying-Boat Hulls

To the Editor of the SCIENTIFIC AMERICAN SUPPLEMENT:

In the SCIENTIFIC AMERICAN SUPPLEMENT of March 6th, 1915, is an article by Mr. Carl Hawes Butman, relating to experiments conducted at the Model Basin in the Washington Navy Yard under the direction of Naval Constructor H. C. Richardson, and a report, which has been published by the Langley Aerodynamical Laboratory of the Smithsonian Institution.

Mr. Butman says: "A model was designed to obviate the defects of the flat scow-bow type, by introducing the V type bottom for parting the water rather than forcing it aside. An earlier model of the V type caused a great amount of spray, and to overcome this the V section was made full, but as this only increased the spray, the V sections were made hollow, which brought about the desired results; holding the spray down, increasing the planing effect, and reducing the resistance."

I beg to make the criticism that anyone reading the above paragraph, and other portions of Mr. Butman's article, would get the impression that the department at Washington had made some new discoveries and created radically new designs. In other words, that this department had discovered the advantages of hydroplane hulls having a V section, and preferably concave V sections, and, as a result of such discoveries, had perfected models which obviated the defects of the flat scow-bow type.

It appears to me that Mr. Butman's article is rather partial to the department at Washington because, if he is familiar with the development of the hydroplane, he knows that the writer had designed and produced hydraulic boats a number of years prior to the date of the experimental work at Washington, and that such boats had concave V sections.

I have read Mr. Richardson's report published by the Smithsonian Institution, and also a similar paper read by him and published in a technical journal, and, in view of the fact that he attaches so much importance to the V type of hydroplane, think that it would have been only fair and a courtesy in keeping with the etiquette of his profession to have made some reference to my work in this direction.

Mr. Richardson in his paper gives Naval Constructor Hunsaker credit for suggesting a formula, a matter of insignificance in comparison with the discovery of new principles and designs which have revolutionized high speed boats, and probably will be of inestimable value in flying boats.

The writer spent several years in France developing the hydroplane, beginning in 1907, and was the first to discover, design and build hydroplane boats having the V section, and the first to adapt hydroplane principles to boat-shaped hulls.

Aside from the discovery of principles, I produced practical designs which are closely copied to-day. I also published in English papers in 1909 and 1910 a number of articles giving much information covering the hydroplane subject, part of which has been verified at later dates by different experiments in the Model Basin at Washington.

WILLIAM H. FAUBER.

Brooklyn, N. Y.

A Correspondent writing in *Power* says: "A telephone receiver has been my constant friend for years, for various uses, one of which is in connection with calipering, especially the work inside of engine cylinders. The most convenient way is to have the two sides of the calipers insulated from each other. The work in the lathe completes the circuit, causing a click in the receiver. An ordinary pair of calipers may be used with a cigarette paper between the work and one side of the calipers.

Rendering "Prometheus" with colors. As the orchestra played light of changing hue illumined the screen.

The Art of Mobile Color

And a Discussion of the Relation of Color to Sound

By M. Luckiesh

THE dream of an art of mobile color is by no means of recent birth. Doubtless for centuries such a possibility has dwelt in the imagination of artists and investigators in color science. Yet the realization of such a dream is perhaps many years in the future owing chiefly to the fact that definite constructive investigation has not been directed toward the mysteries of the emotive and expressive value of colors. That mobile colors may be employed in such a manner as to make a somewhat similar appeal through visual perception as sound music does through the aural apparatus, certainly appears no more improbable than did the solution of many of the mysteries of yesterday. The development of such an art probably will not be left to a single branch of science but experimental psychology must furnish a large part of the constructive data upon which such an art will be founded.

It is the object of this brief article to suggest the general trend that the investigation must take, after discussing some of the superficial attempts that have been made to relate colors and sounds. Therefore the subject will be treated from two viewpoints; first as to relation of colors and sounds, and second from the viewpoint of an art of mobile color, independent of any other art. The treatment from the first viewpoint is not entirely one of choice. In fact one interested in the development of an art of mobile color, independent of any other art, feels compelled to discuss the possibility and justification of such a relation, because in the few instances that colors have been related to sound music the superficiality has been quite apparent. It is significant that the names of these "inventors" are not found among the experimental psychologists and other investigators who are unearthing information that may some day form the foundation of an art of mobile color.

In 1869 J. S. MacDonald in a book entitled "Sound and Color," attempted to relate sounds and colors by affixing to the "seven colors of the rainbow" the "seven notes in the musical scale." He hoped that by such a relation they "might prove to be perfectly analogous in their relative properties and effects either in single sequence, or in combination." His object was to make practical use of the principles of musical harmony in painting, or in the association of colors in matters of dress or decoration. Painting as an art is on a par with music, but the latter as a science is certainly in advance of the fine arts.

Rimington, a few years ago, in a book entitled "Color-Music," repeatedly compares colors and sounds owing to the fact that both "are due to vibrations which stimulate the optic and aural nerve respectively." He further states that "This in itself is remarkable as showing the similarity of the action of sound and color upon us." He presents other "similarities" but in fairness it should be noted that he states that too much weight should not be given to them. Nevertheless, owing to the repeated citations by Rimington of these "similarities," one concludes that they influence him considerably in developing his so-called "color-organ." The same general criticism applies to MacDonald's theory, as well as to practically all of the writings upon the relation of colors and music.

There is no physical relation between sounds and colors. Sounds are transmitted by waves in a *material* medium, as proved by many experiments. Light rays are *supposed* by many to be transmitted by a *hypothetical* medium called the ether, but scientists do not agree as to the *existence* of an ether. Furthermore, the two kinds of wave motion that are used, for convenience, to represent sound and light respectively are *necessarily* different, because the former can not be polarized while the latter can be. These few fundamental differences are sufficient to prove the futility of any claims that sounds and colors are produced in similar ways.

Now let us consider the perceiving organs. The ear is analytical because a musical chord can be analyzed into its components. This is not true of the eye; that is, the eye is a synthetic instrument incapable of analyzing a color into its components. Many colors can be produced by various mixtures of spectral colors. For instance a spectral yellow can be matched by a mixture of red and green spectral lights. The eye can not distinguish between these two yellows. This difference in two organs must necessarily influence the choice of a fundamental mode of producing "color music."

Recently a musical composition by A. Scriabine entitled "Prometheus" was rendered by a symphony orchestra (as described in the *Scientific American* April 10, 1915, p. 343) with the accompaniment of colors according to the "Luce" part as written by the composer for the "Clavier a lumieres." No clue is given in the musical score regarding the colors represented by the notes in the "Luce" part, or the manner in which a "color chord" is to be played—whether by juxtaposition or superposition. The latter is of fundamental importance inasmuch as the eye is not analytical, and a mixture of the colors of a "color chord" results in a single hue. Some of those responsible for the rendition of this music with the color accompaniment had at different times, previous to the final presentation, accepted both the Rimington scale and the Scriabine code (the latter having been discovered after the experiments on the "color instrument" were well under way) as being properly related to the music. These codes as shown in the table are quite different. In fact the colors represented by certain notes are sometimes actually complementary. The original acceptance of the Rimington scale, in the absence of Scriabine's code, as being adapted to the music, and the final acceptance of the latter code, which was used in the public presentation, shows that at the present time there is no definite relation between colors and music, even in the minds of artistic interpreters of music. It must not be assumed that the colors in the table bear any absolute relation to the corresponding notes, for they do not. Those familiar with the science of color would hardly consider it probable that a composer of music would hold the key to "color-music" when they freely acknowledge their helplessness in definitely relating colors and musical sounds. We are yet quite ignorant of the philosophy of the representative or allegorical power of music, and our knowledge of a similar power of colors is almost infinitely less. Everything pointed to a failure in the rendition of "Prometheus" with the accompaniment of colors, and if one is to agree with the critics, after allowing for a considerable degree of conservatism and inertia, the relation of the colors and musical sounds was worse than indefinite, distracting, and unsatisfactory. Considering that the experimental work has not yet been done which should form a basis for expression and arousing emotion by means of colors, no other outcome of superficially relating colors to sound music could have been expected. Even though this be a progressive age it is not likely that color music can evolve, in an acceptable form, from the imagination of any one person. The mechanical construction of the color instrument was ingenious but no more intricate than many flashing signs on Broadway, and not as original as many color mixing devices used daily by experimenters in color science.

While it appears that the art of mobile color must evolve from fundamental experimental data on the

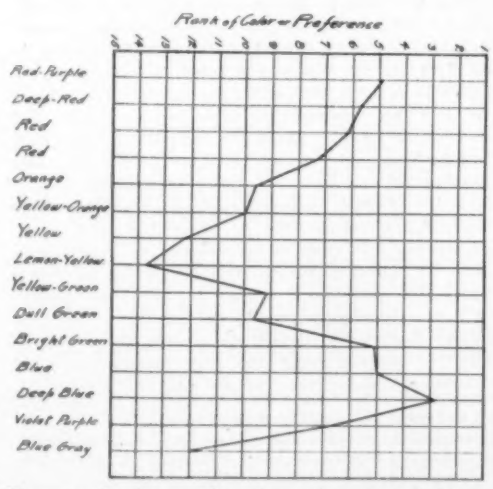
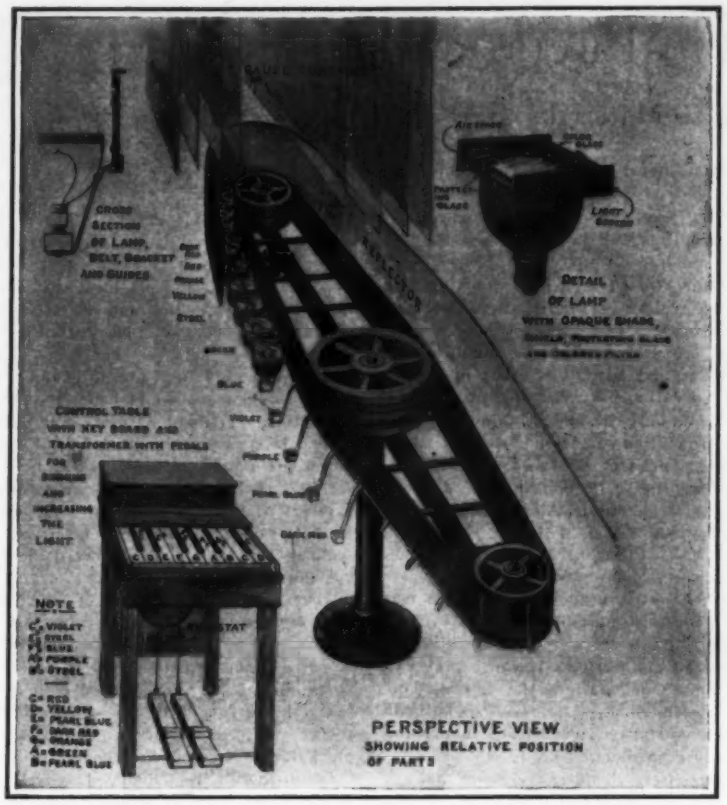


Diagram showing results of experiments with fifteen observers.


CROSS SECTION OF LAMP, BELT, SOCKET AND GUIDES
DETAIL OF LAMP WITH OPAQUE SHADE
CONTROL TABLE WITH KEY BOARD AND TRANSFORMER WITH PEDALS
NOTE
PERSPECTIVE VIEW
SHOWING RELATIVE POSITION OF PARTS

The mechanism of the color piano used in the production of Scriabines' "Prometheus" at Carnegie Hall, New York.

"emotive value" of colors, of simultaneous and successive contrasts in brightness and hue, and of rhythmic sequences in hues, tints and shades it is interesting also to experiment with colors in relation to music. However, a safe elementary procedure in the latter experiment is to use colored light merely to provide the "atmosphere," and gradually to introduce the element of varied intensity and possibly, rhythm. Certainly it is far less presumptuous to use color in this manner, in the absence of experimental data, than to attempt to play a "tune" in colors as a part of a musical score. In providing "atmosphere" for a particular motif such superficial associational relations as blue-green for rippling water, and orange-red for fire (because artists paint them thus), are insufficient. It is the deeper emotional relation that is desired which cannot be determined with certainty without many careful experiments.

In developing an independent art of mobile color what procedure shall be adopted? Certainly the fundamental experiments will be found in the realm of psychology. The aim of the modern artist is not totally unrelated to the subject, and a group of such artists perhaps would form a most interesting audience for these experiments. The new movement in the theater which is striving for harmony in action, lighting and setting, is not wholly unrelated to the subject under consideration. The study of the evolution of sound music is likewise profitable and encouraging. A thought that naturally comes to us is this: Is there anything in Nature that suggests color music? Perhaps scenes full of color may be suggestive of the "atmosphere" colors for musical compositions. Perhaps if the cycle of appearances of such a scene throughout a day were compressed into a period of five minutes, it might suggest what a composition in the art of mobile color would be like. When one begins the experimental work he is appalled at the immensity of the work to be done. The available psychological literature yields some interesting information. Some work on affection pertaining to colors has been done; however, the work which eventually will form a definite basis for developing an art of mobile color, has hardly been begun. As an illustration of the character of the elementary experiments to be performed, the mean results obtained from fifteen observers on the preference for fifteen colors are given in the accompanying diagram. These colors ranged throughout the spectrum and included purples. Nearly all the colors were as saturated (pure) as possible. The fifteen colors, each four inches square, were placed upon a white surface as far apart as possible. The subjects were asked to survey the colors and pick them out in the order of their preference. They were further instructed to isolate the colors as far as possible from everything, and choose them for color's sake alone. The mean rank of the colors were as shown, the lemon yellow ranking last. It is seen that there is a definiteness and consistency in the preference orders of these observers for the mean rank of the lemon yellow for instance is not far from last. It ranked about 14 and there were only 15 colors from which to choose. The most saturated (pure) colors were preferred, and these were near the ends of the spectrum and also included the purples. These results agree in general with those obtained by Cohn, Bradford, Titchener and others, although these various investigators used different methods. There is some evidence that subjects who are less capable of isolating the colors, that is, more inclined to associate them with other experiences, prefer the tints and shades. Space will not permit of a detailed account of such experiments, but the foregoing is cited as one of the simple means of attacking the problems to be solved before the art of mobile color can be supplied with a foundation.

All the known principles of harmony and contrast of colors are available for use by the pioneer in the art of mobile color. The "emotive value" of various hues, tints and shades, of simultaneous and successive contrasts in hue and brightness, and of rhythmic sequences in hue and brightness must be determined. While a color may be most highly preferred among a large number of colors, the "emotive value" of this color is perhaps rather low as compared with many other experiences. For instance a deep blue color may be distinctly more preferred than any other color in a certain group, yet it can hardly be compared in emotive value to a song by one of our operatic artists. As Titchener states, when compared in pleasantness with a good dinner or the scent of a flower the color patch will seem practically indifferent. Of course the results of impressions are only relative, and there is perhaps sufficient emotive value in colors alone to bring success to color music. However, the foregoing point is of interest in combining colors and sound music. Certainly a "color instrument" can not compete with a symphony orchestra, which leads to the tentative conclusion that color in such a relation should be subordinated to the role of merely providing "atmosphere." A color instrument of definite form is conspicuous in its feebleness when in the midst of a symphony orchestra. Such a criticism applies to the recent rendition of "Prometheus."

The mechanical construction of experimental apparatus for studying "color phrases" is simple. Two general methods must be employed at first. In one, the various colors composing a "color chord" are separated physically by playing them on different parts of a white screen, thus introducing the factor of harmony, and overcoming the lack of analytic ability of the eye. In the other the component colors of a color chord are mixed by superposition. Obviously in the latter case harmony is limited to the presentation of colors successively, and the predominant factor in composing color music to be rendered by such an instrument would be that of color-mixture. In the former case the predominant factor would be that of the harmony of juxtaposed colors. In both procedures the element of rhythm and variation in brightness can be introduced. Both types of instruments have been experimented with by the writer, but no great amount of decisive data have been obtained.

The object of this article has been to point out briefly some of the errors of the past, and to suggest the procedure for constructive study with the hope that it will lead to a definite art of mobile color. At present there is no art of mobile color; meager constructive data are available; there have been hardly more than superficial attempts made to present it; psychological studies must be relied upon to point the way toward its development; the field is worthy of cultivation; there are definite problems that must be studied in order to obtain foundation material for building up an art of mobile color.

COLOR CODES.

	MacDonald (1869)	Rimington (1911)	Scriabine (1911)
C	Red	Deep Red	Red
C#		Crimson	Violet
D	Orange	Orange-Crimson	Yellow
D#		Orange	Glint of Steel
E	Yellow	Yellow	Pearly blue and shimmer of moonshine
F	Green	Yellow-Green	Deep red
F#		Green	Bright blue
G	Blue	Bluish green	Rosy orange
G#		Blue green	Purple
A	Indigo	Indigo	Green
A#		Deep blue	Glint of Steel
B	Violet	Violet	Pearly blue and shimmer of moonshine
C	Red	Invisible	

Radium Treatment of Cancer

THE American Society for the Control of Cancer fears that exaggerated ideas of the power of radium in the treatment of cancer may result from the recent publicity given to this agent in the daily press. It appears highly important at the present time that the limitations of radium in the control of cancer should be emphasized as well as its favorable effects in certain cases. Otherwise the familiar story of new hopes, destined only to disappointment, will again be recorded at the expense of many unfortunate sufferers.

The curative effects of radium are practically limited to-day to superficial cancers of the skin, to superficial growths of mucous membrane which are not true cancers, and to some deeper lying tumors or bone, etc., which are not very malignant. The problem of the constitutional treatment of advanced, inoperable cancer is still untouched by any method yet devised or likely to be devised for administering radium. Even among the so-called radium cures, it still remains to be determined in many cases whether the favorable result is permanent or is to be followed sooner or later by the usual recurrence. The most competent surgeons do not dare to pronounce a case cured until five years have elapsed after an apparently successful operation. The same test must be applied before we can finally determine the real value of radium.

It should be emphasized especially that radium cannot at present exert any permanent benefit on generalized cancer, and since cancer, in a very large proportion of cases, is widely disseminated in the body early in the course of the disease, this entire group of cases can expect no important relief from radium. Another large group of cancers is comparatively inaccessible to the application of radium, so that the ultimate course of the disease is not effected, although certain portions of the tumor may be reduced in size. Again, many forms of cancer, although localized and accessible to radium, grow very rapidly and resist the curative action of this agent, so that no real benefit can be expected from its use.

The best results of radium therapy can be secured only when comparatively large amounts are available for use and the present limited world's supply of this metal places it out of reach of the great majority of patients. It is to be feared that much harm may result from undue reliance upon small quantities of low grade radium when other methods of treatment would be more effective.

Evidence of the possible extent of popular misconception on this subject is found in a pathetic letter recently received at the New York Health Department from a sufferer in California who had somehow obtained the impression that the United States Government was about to purchase large quantities of radium from abroad. Assuming that the "New York city physician" would have a plentiful supply, the writer asked that some be sent to him C. O. D. without delaying to advise him as to the cost.

Under the term "cancer" are commonly grouped several diseases which differ widely in nature, causation, and courses, and in their response to radium. It requires both skill and experience to determine just what type of cancer one has to deal with as well as the advisability of using radium. Hence, it is extremely difficult to formulate an accurate statement of the true positions of radium therapy, but it is quite clear that the exploitation of this remedy as a cure of cancer in general is to be deprecated.

Floor Surfaces in Fireproof Buildings

Recommendations in Regard to Material and Methods of Construction

By Sanford E. Thompson

In fireproof construction, whether it be office building, factory, or institution, the question of the type of floor surface to select and the method of construction to adopt is a most important one. The constant tread and shuffling of feet cause a friction that it is difficult to withstand without serious wear.

From the construction standpoint, in a non-combustible structure a cement surface is in keeping with the rest of the building and is naturally the first considered. In many instances the cement concrete or granolithic floor has proved extremely satisfactory, while in others, because of the use of improper constituents, of inexpert construction, or of its selection for places to which it is not adapted, it has proved a disappointment. As a matter of fact, no one type of floor surface is adapted to all conditions, while for any type that is properly selected, the choosing of the material and the manner of the construction will govern to a large extent the durability of the surface.

It is the purpose of this paper to discuss briefly the different kinds of floor surfaces, and to compare their various qualities, their cost, and their adaptability to specific conditions. This is followed by a more detailed treatment of the methods of constructing the concrete or granolithic surface which have produced satisfactory results.

An engineer in consulting practice is called upon frequently not only to design and construct but to investigate defective construction and also to make special tests for the determination of the best methods to employ in a particular case. In this paper are embraced not only the results of experience in floor construction and repairs, especially as they relate to granolithic surfaces, but also the conclusions derived from special tests and investigations made in connection with services as consultant on the superstructure of the New Technology buildings in Cambridge.

The selection of the type of floor is dependent on the character of the structure, the nature of the wear, and the architectural appearance. Every building must be considered by itself. Suggestions for the type of surface to select are covered in the following pages. As a preliminary guide, the material suitable for different conditions may be given as:

Basements: Granolithic finish with troweled surface made with approved materials and workmanship.

Factory Floors: Granolithic finish with troweled surface; hardwood.

Machine Shops: Granolithic finish with troweled surface; hardwood on substantial base.

Ground Floors for Heavy Manufacturing: Wood block; granolithic.

Warehouses: Granolithic with troweled surface; asphalt composition; hardwood.

Offices: Hardwood; linoleum on concrete; magnesium composition.

Corridors and Halls for institutions and office buildings: Terrazzo; granolithic finish with ground surface.

Entrance Pavilions: Terrazzo; mosaic; tile; natural stone.

Class Rooms, Lecture Rooms, and Drawing Rooms: Linoleum on concrete; granolithic with ground surface; hardwood; magnesium composition.

Laboratories: Granolithic with troweled surface; magnesium composition; tile; hardwood.

Lavatories: Terrazzo; granolithic finish with ground surface; tile.

The above selections are given in the order in which choice might be made for the average building or room of each class.

CHARACTERISTICS OF FLOOR SURFACES.

Granolithic Troweled. As ordinarily laid in buildings, granolithic or concrete surfaces are subject to dusting and under heavy traffic, such as trucking, are liable to serious wear. On the other hand, experience with first-class construction and tests of actual floors shows that it is possible, by proper selection of the aggregates and expert workmanship, to reduce the dusting to an insignificant amount and to produce a surface hard enough to stand even severe wear.

For factory floors, notwithstanding many cases of inferior construction, the use of granolithic is largely increasing. It is becoming recognized that the durability of granolithic is in a very large measure dependent upon the sand or other aggregates used in the construction and the methods of laying it.

The chief objection to concrete or granolithic surfaces for offices, drafting rooms, class rooms, and certain laboratories, is that it is dull in appearance, hard on the feet for men standing all day, tends to break tools dropped upon it, and is not adapted to attaching seats and other furniture readily, especially where they have to be shifted occasionally. In certain colleges, however, concrete surfaces are used widely and highly recommended. At Bowdoin and at the University of Wisconsin it is considered satisfactory for all purposes. At the University of Missouri the newer buildings are all being built with granolithic surfaces. In some colleges granolithic is being satisfactorily used for corridors. Most of the colleges favor granolithic for chemical, mining, and mechanical laboratories. The Leland Stanford, Jr., University states that in the mechanical and engineering laboratories the men complain of hardness and coldness, requiring wood platforms in many places. In this university, however, granolithic has been used in the chemical laboratories for fifteen years with excellent satisfaction. It should be noted, further, that in the mechanical and engineering laboratories the floor rests directly on the ground, while in the chemical laboratory there is a warm room or basement underneath. The life of a well laid granolithic surface under foot traffic is practically permanent.

Granolithic with Ground Surface. Experimental surfaces, together with laboratory tests made as a check, show that a pleasing surface, approaching terrazzo in appearance and fully as durable under foot traffic, can be obtained by placing granolithic with scarcely any trowelling, and then grinding the surface just enough to expose the grains of sand and stone. The grains which show are finer than in terrazzo and darker colored. The appearance, however, is pleasing. Removal of the scum takes away the monotony of the plain gray cement surface, since this is relieved by the various colors of the sand and stone. A glossy effect can be produced if desired by the grinding which permits of easy cleaning and gives a surface suitable even for a lavatory at much less cost than tile or terrazzo. Still further to give variety to the appearance, tile can be placed in patterns or as a border.

The University of Missouri, which refers to the dust from granolithic floors, believes that this difficulty would be solved by grinding the surface instead of trowelling. Specifications giving the method of laying the concrete granolithic and grinding it are presented at the end of this paper. From observations of the time required for grinding the surfaces and allowing amply for delays, the extra cost for grinding is estimated not to exceed 3 cents per square foot of surface area.

Linoleum. The hardness and noise characteristic of granolithic finish are overcome by covering the surface with Battleship linoleum. In the few colleges where this has been adopted they are very enthusiastic over the results. In other places, such as offices, the same type of construction meets with a great deal of favor. At the University of Chicago cork carpets are used, which answer a similar purpose.

Linoleum is laid on a concrete surface, which need not be brought to a fine finish, and therefore can be completed at the time the base concrete is laid and at a low cost. Any marring of the surface or sudden rains will not affect its use for the linoleum finish.

The linoleum should be stuck firmly to the granolithic surface and preferably a cove base should be run around the room and sills provided at entrances so that the surface of the granolithic will be flush. In this way the edges are prevented from fraying. The life of first-class quality Battleship linoleum, if edges are not frayed, is probably from fifteen to thirty years, depending upon the amount of travel. These ages are estimated from records of linoleum now in use.

Linoleum, after allowing for the better finish required on the concrete, costs substantially the same as a single floor of birch or maple, but it is noiseless, more uniform in appearance, and requires less labor for maintenance in good condition. Its superiority to wood is indicated by the fact that wood floors are frequently covered with linoleum.

Hardwood Floors. Floors of maple, birch, beech, oak, or long leafed Southern pine are used most largely for offices, class rooms, or lecture rooms, and in many of the older colleges for laboratories and halls. A wood surface, however, is not usually considered entirely satisfactory either in general appearance or in wearing qualities. If one passes from a corridor with a granolithic, terrazzo, or tile floor, into a room or auditorium having a wood floor, there is a marked effect of inferiority and cheapness. There is just as much danger of poor materials and workmanship with wood as with other kinds of floors. Unless the greatest care is taken in selection of materials and workmanship, they are liable to shrink or swell and sometimes to squeak under foot. If at all hollow underneath, they are more noisy than a concrete surface. The floors of the New Grand Central office buildings are an example of this.

For corridors, wood is being largely superseded by granolithic, terrazzo, or tile. For laboratories other materials are being substituted for wood in most of the newer structures, although wood is occasionally preferred, especially for physical laboratories and for laboratories where men stand for long periods. The linoleum on concrete will overcome practically all the objections that are made to wood floors, with a cost substantially the same.

There are various methods of laying hardwood floors. For class rooms a single thickness of maple or birch nailed to sleepers with cinder concrete between should be satisfactory. Another type of construction is to use patented metal screeds embedded in the base concrete, and nail the floor boards to splines in the screeds. For rooms subjected to heavy traffic, 2-inch or 2½-inch plank may be placed underneath the hardwood floor.

Of all the different materials, oak is the most expensive and the finest in appearance at the beginning, but under heavy traffic is more liable to splinter than the finer grained woods. Georgia pine, if of best quality, makes a durable floor, and is preferable to the finer grained woods in wet places, as it does not swell and warp so badly. It is less durable, however, and therefore not recommended for the greatest permanence in rooms such as class and lecture rooms. Maple, birch, and beech all make good floor material. These are usually laid in strips ⅞ inch thick by 2¼ inches wide. The quality varies largely, ranging in cost from $32 to $75 per 1,000.

Terrazzo. Terrazzo is made by spreading upon the base concrete a mixture of neat cement and marble chips and grinding the surface to a depth sufficient to cut into stones and expose them on their largest diameters. Marble, sometimes white and sometimes colored, is used, and since no sand is employed the particles may be of fairly uniform size. The joints between the particles being of neat cement are hard and even more durable than the pieces of the marble themselves. Large pieces of marble, from ¾ inch to 1 inch in diameter, give a more distinctive floor but cost more than a floor of the smaller stones, from ⅛ inch to ½ inch in diameter, because the large stones require much more grinding to get down to the large diameters of the particles. There is more tendency to crack than in a good granolithic properly bonded to the base, but if laid with the best workmanship, this cracking is reduced to a minimum. Terrazzo is largely used, especially in the newer office buildings and in institutions, for corridors and halls. It also is satisfactory for lavatories, although more expensive than granolithic. It appears from our investigation that for both of these uses concrete with a ground surface can be substituted at less cost and with satisfactory results. In certain cases objection—which applies also to any hard material like granolithic or tile—is raised to terrazzo because of the noise, and even corridors are covered with linoleum or similar material.

Marble Mosaic. Mosaic consists of small squares of marble laid on the cement bed, something like terrazzo. Surfaces are ground enough to make all pieces true and level. The price of mosaic is too high to be considered for large areas and in many cases the pieces of marble pull out from the surface. Mosaic is suitable in certain cases for an ornamental border which is not subject to wear.

Magnesium Composition. When laid with great care, composition is a satisfactory and durable material. Floors six or eight years old have been examined and show satisfactory wear. The work must be done by a responsible firm with a suitable guarantee bond, because even with the greatest care the work is occasionally imperfect. The imperfections, however, are apt to show within the first year of service. Composition is more resilient than granolithic, so that there are less complaints of hardness. It is nearly, but not quite, as noisy. Furniture can be screwed directly to the composition. Composition has not yet been used to a great extent in colleges. The floors of Cooper Union in New York city are many of them covered with this material and the results have been satisfactory. It is suitable for cer-

* From a paper read before the American Society of Mechanical Engineers.

tain school laboratories, such as physical and biological.

Asphalt Composition. Asphalt composition is suitable for certain places where no heavy tools or machines are liable to press into the soft surface. It is resilient and easy to walk and stand upon. The color is not pleasing, being a dead black. In a few colleges it has been used satisfactorily for chemical laboratories. At Harvard, for example, asphalt mastic on top of wood has been in satisfactory use for many years. Johns Hopkins considered this material for their new chemical laboratories but abandoned it because of its viscous properties, substituting granolithic finish, which has proved satisfactory.

Tiles. Tiles of various colors is an excellent material for corridors, lavatories, and even for laboratories, but is too expensive to use except where required for architectural treatment. There are various types and qualities of tile, ranging from quarry tile to cork and rubber tile. All of them, however, are expensive.

Wood Block. Wood block may be suitable in certain cases for a basement floor having severe usage. In the University of Cincinnati wood block is used in the mechanical and electrical testing laboratories and appears to be satisfactory.

TESTS AND INVESTIGATIONS OF GRANOLITHIC FLOORS.

The material used most largely for floor surfaces in factory construction and also to a considerable extent on other structures is what is termed a granolithic surface. This, as generally understood, is a layer of mortar or concrete from ½ inch to 2 inches thick, usually about 1 inch on top of the concrete slab and bonded to it. Although granolithic or concrete floors are so widely employed, neither the materials nor the methods of construction are standardized and scarcely two contractors or engineers adopt the same methods. Moreover, the materials available in a given locality largely affect the choice.

In order to compare the materials, that is, the aggregates, available for new Technology, and to determine the best proportions and methods of laying these materials, a series of sample surface were laid at the factory of the Simplex Wire and Cable Company, in Cambridge. Also, comparative tests were made with similar materials in other locations. A few preliminary laboratory tests were carried through, and certain tests to determine the best method of bonding a new granolithic surface to a hardened concrete base. As a result of these experiments, the following recommendations are made for the granolithic finish of floors for which this material is to be used. The conclusions apply also to structures in general.

Materials. The various aggregates used in the tests include three kinds of sand mixed as mortars in different proportions, and combinations of these sands with samples of different granites and traps. One or two sections were also laid with a patented compound.

Careful examination and comparisons of the various sections of slab with reference to hardness and appearance led to the selection of Plum Island sand, which should be specified to have not more than 10 per cent of its grains pass a sieve having 50 meshes to the linear inch, and not more than 2 per cent pass a sieve having 100 meshes to the linear inch; and crushed granite of a size which has passed the ¾-inch screen in a crusher plant and been caught on the ⅜-inch screen.

As a result of this selection, a slab of considerable area was laid at a later date at the Simplex factory with the selected materials and proportions, and in a position where it would receive rather hard usage. The Simplex Company have recently advised us that they consider this slab the best piece of granolithic that has been laid in the factory.

Proportions. Different proportions of the materials were employed in the various sample sections, each of which was about 2 feet wide by 3 feet long. The principal proportions tested were 1:2, with sand alone; 1:1½ with sand alone; 1:1:1¼ with sand and fine crushed stone; 1:1:1½ with the same materials, and 1:¾:1¼. As a result the proportions selected as best are one part cement to ¾ part Plum Island sand to 1¼ parts crushed granite.

Method of Laying Granolithic. Instead of using a soft, flowing mixture, the best results were obtained by using a fairly stiff mixture, stiff enough to be rammed in place by a square-faced rammer, which would bring the mortar readily to the surface. In this way the surface skin is thinner, there is less liability to dust, and the body of the concrete, which is of a better quality than with a wetter mix, is reached with comparatively little wear, so that the dusting does not continue.

Treatment of Surfaces. Dusting is temporarily overcome by paint, but this is always unsatisfactory because it wears off under ordinary travel, and if the concrete is not of the best quality it then begins to dust.

Grinding Surfaces of Granolithic. Objections to granolithic finish are dusting of the surface, the dead gray color, and the liability of local defects. Experiments show that these can be overcome by grinding the surfaces with a carborundum machine. This method was followed on a section of slab at the Simplex Wire and Cable Company.

The general plan adopted is similar to that used with terrazzo finish. Instead, however, of grinding off a considerable thickness and thus entailing a large expense per square foot, only a very thin layer is taken off so as to show the grains of sand and the pieces of coarser aggregate. With this treatment, the surface is of a varied texture, and shows the various colored grains, and permits of different effects by using aggregates of different colors. While the effect is not so conspicuous as the terrazzo, the surface is of a quieter tone, and should be satisfactory for ordinary corridors and halls. The grinding renders the surface more glossy and denser, so that it is possible to use this treatment with good results in a lavatory or other places where frequent washing and cleaning is required. To produce a more ornamental effect, borders or patterns of tile may be placed in the concrete.

Bond of Granolithic to Base Concrete. A perfect bond between the granolithic and the base concrete is obtained most easily by placing the granolithic before the base concrete has reached its set. Surfaces thus laid are liable to injury from the workmen who have to go upon them before they have hardened thoroughly, and occasionally an unexpected shower will roughen the surface in such a way that it is very difficult to repair. To determine the best method of bonding, one which would give thorough assurance of perfect adhesion, tests were made and then tried out in the field on a large concrete building.

Laboratory tests were made on bonding new mortar to an old concrete surface, using various methods of treatment of surface, including acid treatment, roughening, and no surface treatment whatever. As bonding material, neat cement was used in different conditions of plasticity, also certain patented compounds. As a result of these tests and experience in the field, a roughened surface of the old concrete, with neat cement paste brushed in, is recommended as an effective method to produce a positive bond. It was shown in the tests that with a proper neat cement bond on a roughened surface the break under tension was frequently through the concrete rather than at the joint.

Preparing Concrete Base for other Surface Materials. If some other material than granolithic is used for the wearing surface, the base concrete must be left in a condition satisfactory for placing the surface. For most materials, such as hardwood finish, composition, asphalt and similar treatments, the surface of the base must be brought more nearly level than where granolithic is used. This can be accomplished by very careful screeding of the surface, trowelling of rough places, and filling holes made by footprints before the concrete has hardened.

For linoleum, a real granolithic is not required, but the surface must be level and true. This should be accomplished by spreading a thin layer of mortar before the base concrete is set, but this need not be of the very best quality of granolithic unless with the object of using portions of the floor without linoleum. This thickness of the mortar may be ½ inch to ¾ inch. This should be troweled at the proper periods, but with less care than for a granolithic that is to be used as wearing surface. Some form of cove base around the walls is advantageous to use with the linoleum.

High-Speed Engines*

For the last four or five years we have been producing in some of our factories on the other side high-speed engines which will run successfully in touring automobiles without any more trouble than the ordinary slow-speed engines. In fact, five years ago the company I was connected with were in a position to give a three years' guarantee with their automobiles, the engines of which ran at a maximum speed of about 2,500 to 2,600 revolutions per minute. Within the last two or three years we have been producing engines which have been developing maximum power at 2,400 revolutions per minute, and these have accelerated to 2,800 revolutions per minute on the slightest down grade. These particular automobiles have not only been successful in the British Isles, but have been highly satisfactory and successful in our colonies, such as Australia, New Zealand, etc., where the roads are, I think, pretty much on a par with American roads. In fact, just before leaving England I inspected a report from one of my assistants who was in Australia looking into the matter. His report, as well as the agent's report on the behavior of automobiles there, not only of our own production but of high-speed-engined cars produced by other firms, was to the effect that they were entirely satisfactory.

I am stating these points because in discussing them with some of the engineers here I have found that quite an erroneous idea seems to exist regarding the durability of the high-speed engine fitted into a moderately light chassis. The chassis which these engines are called upon to pull are not light, being in most cases of about the same weight as some of the modern chassis here. These chassis stand up not only in Britain but also in the colonies. A horse-power represents 33,000 foot-pounds of work, whether it is developed in Britain or in America, and if the required horse-power can be obtained with a smaller engine, greater economy will result. As an example of what has been done, I have designed a four-cylinder engine of 2 11/16-inch bore and 5-inch stroke, which developed 36 brake-horse-power at 2,600 revolutions per minute. It was fitted to a 110-inch wheelbase chassis weighing 1,680 pounds. This automobile could pull on top gear at 10 miles per hour on a very decent grade, in practically the same manner as a six-cylinder automobile with an engine of 3¼-inch bore and 5-inch stroke. The wheelbase of the six was 126 inches and the chassis weight about 2,632 pounds. Both chassis carried a load of driver and one passenger, plus a weight of 896 pounds. The small automobile was only three or four miles an hour slower than the large one. Obviously, the small engine was more efficient and developed a much higher mean effective pressure than the larger engine.

Undoubtedly, the most efficient valve mechanism which can be designed is the overhead system, because the combustion chamber is more perfect and presents less cooling surface to a given volume of gas than any other arrangement. This arrangement has, however, an inclination to become noisy, as, due to the inertia of the valve gear, which is undoubtedly greater than with any other type and naturally requires correspondingly stronger springs to prevent valve chatter, the rocker pins, etc., soon develop a certain amount of play or wear, especially if the engine is of the efficient high-speed type. If the engine is not of this type, there is no necessity for overhead valves.

One can get highly satisfactory results with the exhaust valve in the orthodox position and the inlet overhead. With this arrangement about 15 to 25 per cent more charge can enter the cylinders for a given size of valve than with the L-head type of motor. The power of a motor depends largely upon its volumetric efficiency.

I have been astonished to find how many of the engineers on this side still favor the T-head type of motor. I have found this arrangement to be the least efficient on record, it being necessary in order to get even moderate efficiency to use a two-spark magneto with spark plugs on either side of the combustion chamber. I have proved this contention more than once. It has also been proven by the fact that two spark plugs make very little difference in the L-head type of motor, no matter in what position they are placed.

For ordinary sizes of racing motors it is, in my opinion, entirely unnecessary to fit multiple valves unless it is desired to run the engine somewhere about 5,000 revolutions per minute, or unless the bore of the cylinder be so large and the stroke so long that two ordinary valves would be entirely too large. Regarding the design of valves and valve gear generally, I would say that lately I took part in some experiments with an engine running at 4,000 revolutions per minute and developing power at that speed, the valves being side-by-side in the conventional L-headed manner. The results were certainly astonishing.

I have been using in my own automobile an engine which developed full power at 3,000 revolutions per minute, the bore being 3 1/8 inch and the stroke 5 1/8 inch. The wheelbase of the chassis was about 126 inches and the weight about 1,900 pounds. This automobile could touch about 70 miles per hour in touring trim, with open torpedo body but no wind screen. The acceleration was good from about 7 miles per hour an hour on top gear.

* Paper read by D. McCall White and published in the *S. A. E. Bulletin.*

Railway Rail Production and Failures

BULLETIN No. 170 of the American Railway Engineering Association dealt with statistics of rail failures furnished to the American Railway Association by various, but not all, of the railways in the United States and Canada. These show that during the year ended October 31st, 1913, there were 63,472 tons rolled on the Bessemer process and 703,557 tons by the open-hearth process. In 1900, when about the same total tonnage was rolled, the figures were 432,155 for Bessemer and 461,261 for open-hearth. The failures in 1911—the years 1912 and 1913 are too recent to afford any conclusions as to failures—were 37.4 per 10,000 tons of open-hearth rails and 94.2 per 10,000 tons of Bessemer rails, which, taking the open-hearth failures as 100 per cent, means 252 per cent for the Bessemer. In 1900 the open-hearth rails had 109 failures per 10,000 tons and the Bessemer 212.4, which, again taking the open-hearth failures as 100 per cent, gives 195 per cent for the Bessemer. The percentages in favor of open-hearth rails have increased year by year, which, the report says, suggests the thought that there were faulty practices in the early rollings of open-hearth rails since improved upon.

Automobile Lubrication—II*

How to Test, and How to Use Various Classes of Oils and Greases

By C. W. Stratford

Concluded from SCIENTIFIC AMERICAN SUPPLEMENT No. 2059, Page 393, June 19, 1915

CONDITIONS UNDER WHICH MOTOR OILS WORK.

THESE may be treated under three headings: (1) Division of lubricating system; (2) Operating temperatures of motor parts; (3) Requisite physical properties and their effect upon motor operation.

Division of Lubricating Systems.—A thorough analysis of the lubricating systems of automobile motors, with all their peculiarities of design, in connection with exhaustive tests made with oils in each, shows that practically every lubricating system in use to-day can be included in the following distinct types:

(1) Full Splash.
(2) Splash, with Circulating Pump.
(3) Pump Over and Splash.
(4) Force Feed and Splash.
(5) Pump Over.
(6) Separate Force Feed.
(7) Force Feed.
(8) Full Force Feed.
(9) Knight Slide Valve Motor.
(10) Oil Fed with Fuel.

The reason for choosing such a fixed number of lubri-

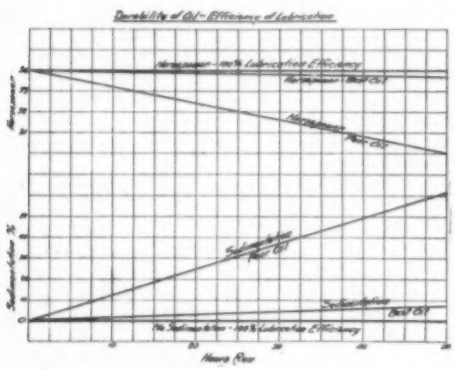


Fig. 11.—Durability of oil and efficiency of lubrication.

cating systems is to facilitate their proper classification and because of the effect which the details of these lubricating systems exert upon the flow of oil to the moving parts. Insofar as the principles involved go, lubricating systems, without exception, can be divided into two general groups, "Circulating" systems and "All-loss" systems. By "all-loss" system is meant a lubricating system in which oil is fed directly into the crankcase, or through the bearings into the crankcase, from an outside source. Oil thus fed into the case never returns to its source. In "all-loss" systems the lubrication of the parts in contact is accomplished by (a) splash only from the connecting-rod ends, and by (b) oil under pressure as well as by splash from the connecting-rod ends. In motors employing "all-loss" systems oil is filled up to a fixed level in the crankcase. The lubrication of all parts is then made continuous by splash and by feeding oil from an auxiliary source into the crankcase, where it is consumed at or about the same rate as the feed. "All-loss" systems are, however, much less fool-proof in many ways than are the circulating. There is a possibility with the former of feeding an excess of oil into the crankcase, which may cause a rapid carbon deposit in the cylinders, or, on the other hand, of feeding too little oil, thereby causing unduly rapid wear, or, perhaps, serious injury to the parts from want of lubrication.

By circulating system is meant a lubricating system in which a quantity of oil is filled to a fixed level into the crankcase sump, whence it is circulated by some type of pump or by the flywheel to all parts requiring lubrication. In circulating systems the oil is applied to the moving parts by (a) splash alone from the connecting-rod ends, or by (b) pressure, and splash from the connecting-rod ends. A drain pocket or cavity should be provided at the lowest part of the crankcase sump in circulating systems so that all metallic sediment, carbon, heavy carbonaceous or foreign matter will settle and not re-enter the circulating pump. Fine mesh metallic screens are regularly fitted between the main crankcase and the oil sump below, or over the inlet side of the circulating pump, as a positive means of separating solid matter, cotter pins, nuts and wrenches from the lubricating oil.

Before leaving the subject of lubricating systems, I wish to state that during my own experience as a designer of internal combustion engines I have frequently been called upon to solve many vexatious and baffling problems most of which had to do with the proper form and arrangement of the lower crankcase, oil sump and its accessories. Very careful attention here to details invariably pays in the long run. The very success or failure of a motor in the hands of a careless public may depend wholly upon their excellence.

* A paper presented at the semi-annual meeting of the Society of Automobile Engineers, June 14th, 1915.

OPERATING TEMPERATURES.

Automobile motor oils are exposed continuously to much higher temperatures in an internal combustion engine than they were in the heat test already mentioned. Especially is this true within the explosion chambers, upon the upper surfaces of the cylinder walls and upon the lower surfaces of the piston heads. For clearness let us examine only the functions performed by the oil and the changes which it undergoes above and below the piston.

Oil for the lubrication of pistons and cylinders is splashed on the lower cylinder walls and from there it is carried upward and spread over the cylinder wall surface by the pistons and piston rings. A certain quantity as well is thrown off the pistons on their ascending stroke and projected onto the entire explosion chamber walls. If the latter quantity is small, and the fuel mixture is set on the lean side, it will be flashed off, leaving no appreciable deposit. But when an overabundance is thrown up, the heat of explosion can only vaporize the exposed surface or outer layers so to speak, of the oil film, because of its poor heat conductivity, and blow it out with the exhaust gases in the form of smoke, leaving behind heavy end-products of destructive distillation. These are rapidly reduced by the intense heat of open-throttle explosions into a cumulative incrustation called carbon deposit in common parlance. The actual free carbon content of this carbon deposit may vary from less than 1 to as high as 75 per cent. Other constituents present are metal oxides, mostly iron, from a trace to approximately 5 per cent, large percentages of inactive earthy matter (road dust) and solid black carbonaceous or asphaltic compounds, according to the oil used. An analysis of crankcase sediment, taken from a laboratory motor, showed free carbon under 2 per cent, metal dust less than 1 per cent, the remainder being nearly equal quantities of carbonaceous matter, (1) soluble in naptha and (2) soluble in carbon disulphid. And the analysis of deposit taken from the crankcase side of the piston heads showed approximately the same percentage of the above constituents, excepting a slight increase in free carbon.

Given an oil of good quality, carbon deposits resulting from its use, up to the point where trouble occurs, can and should be easily avoided between annual overhauls by the manufacturer's proper design of motor parts. While it is a fact that much can be done toward the suppression of mechanical defects, omissions of design and carbon deposits accruing therefrom, by correct oil specifications to suit the case in hand, it is decidedly unfair to suppose that oil alone can satisfactorily replace leaky piston rings, or to burden motor oil with a more exacting task in the cylinders than that of good lubrication with its helpful seal against slight gas leakage.

Below the piston heads, though the heat conditions there are somewhat less severe than above, chemical reactions within the oil are just as inevitable and continuous. No lubricating oil exists that will not undergo a chemical and, naturally, a physical change when exposed to the high temperatures on both sides of the pistons of automobile motors. In other words, there is no motor oil known that will not deposit sediment in the crankcase. A very marked difference does, however, exist in the rate of sedimentation of oils of good and of poor quality, used in the same motor under the same operating conditions. It seems logical to conclude, therefore, that the rate of sedimentation must be a dependable measure of durability and efficiency.

SERVICE TESTS.

For the purpose of the following tests, let us assume that two yellow oils of the same viscosity, say, between 200 and 300 seconds Saybolt at 100 degrees, be used.

Good Oil—Reactions.—When a motor is run on the test stand or in a car for a few hours with a filtered oil of the highest quality and a sample taken for examination, it will be seen that the oil has changed from its original yellow to a grayish-blue by reflected light. After running several days it will be found that the oil has turned entirely black and become opaque. A sample drained from the motor into a long narrow tube and allowed to stand 24 hours will show a black sediment at the bottom. The oil floating above the sediment is red in color by transmitted light and is equally as serviceable as when fresh. The volume of this sediment depends upon the operating temperatures of motor parts with which it has come in contact, particularly the temperature of the piston heads, upon the presence or absence of mechanical defects (leaks) in the motor, and upon the quality, i. e., degree of purity and stability of the oil used.

Poor Oil—Reactions.—Let a poor oil be run in the same motor under like conditions of time and temperatures and samples examined. At the end of a few minutes

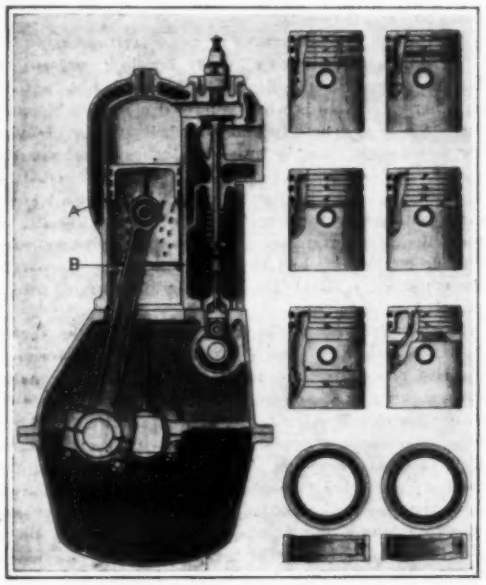


Fig. 12.—Proper design for good lubrication.

the oil will turn to a dense and lustrous black. After standing 24 hours the sample used several days will show a voluminous black sediment, several times greater than that of the good oil.

In the interpretation of these results, let us assume the most favorable case for the poor oil—that the portion remaining above the sediment is still usable, though more often it is not. The good oil is still vastly more durable and economical than the poor. (Fig. 11). Chemically, this low resistance to heat shown by poor oils is again traceable to the nefarious and destructive effect of "sulpho" compounds present. Regarding the probable effect which their presence might have upon the bearings and other parts within the motor, when decomposed by heat into free sulphuric acid, it may be expected that corrosive action would be almost negligible. The effect of hot sulphuric acid gas upon highly heated exhaust valves and seats is very noticeable, however, causing rapid pitting of the surfaces and leakage.

SUGGESTIONS RELATIVE TO DESIGN.

The maximum mileage per gallon of oil in the best modern automobile motor is rarely above 1,000, as compared to that of the average motor which probably never exceeds 200. Why such a wide difference in efficiency? The answer is not hard to find. An examination of the 1,000-mile motor discloses the use of tight piston rings, large centrifugal rings on the crankshaft where it passes through the case, ample cooling fins in the pistons, vents between the crankcase chamber and the valve enclosures, etc. Briefly put, cooling of the oil in this motor has been properly cared for and leakage reduced to a minimum. The result speaks for itself.

To be specific regarding details of design: Oil surplus can be kept out of the explosion chambers by leaving the lower edge of the piston skirt sharp and by the use of a shallow groove just below the lower piston ring (Fig. 12). Small holes are bored through the piston walls at the base of this groove and communicate with the crankcase. The similarity of the sharp edges of piston skirt and piston ring to a carpenter's plane bit, makes their operation plain.

Faulty piston rings are not to be tolerated any more than is their careless fitting. Concentric rings are to be preferred with a maximum clearance between back of ring and bottom of groove, of 0.010 inch. The thickness of piston heads should not only be sufficient for strength but also for good heat conduction. If the bore exceeds

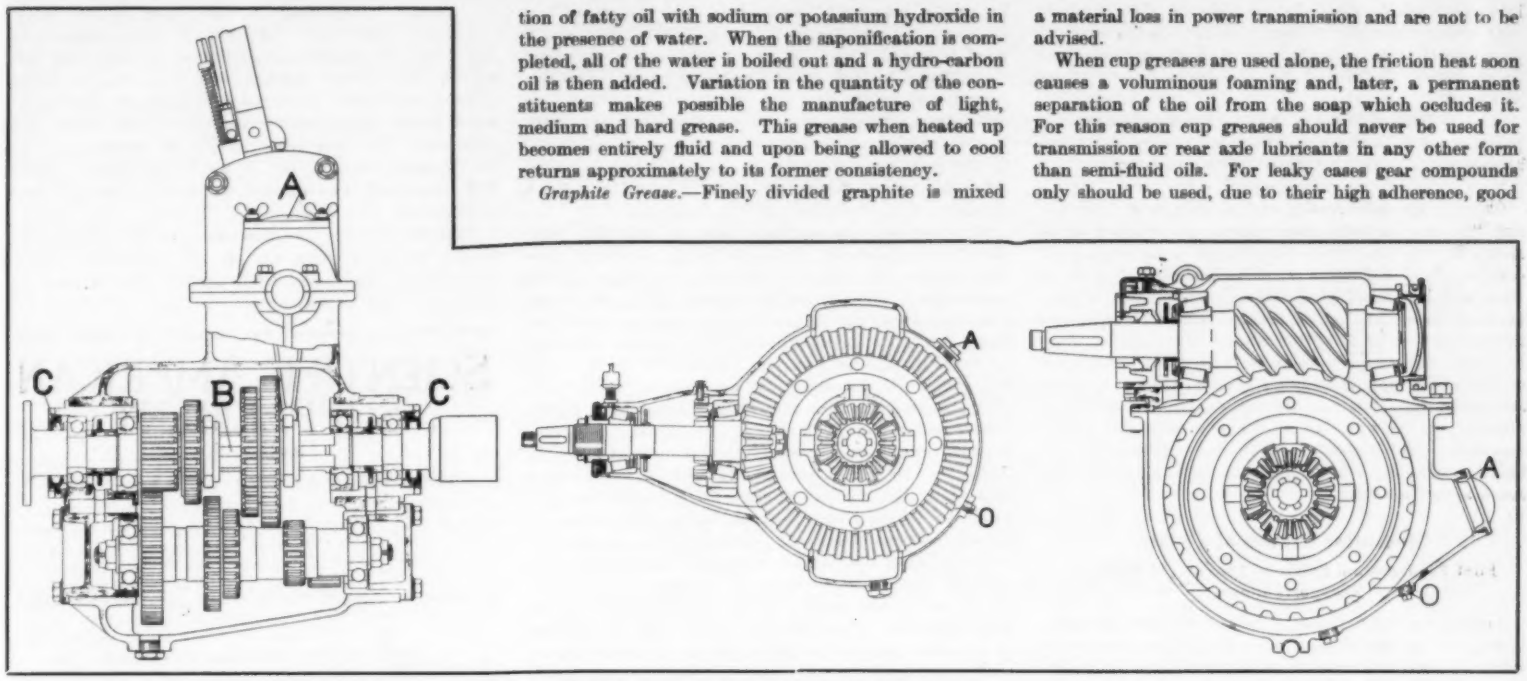


Fig. 13.—Proper design for good lubrication.

4 inches, thin cooling webs should be provided in the head so as to fully utilize the cooling effect of the oil. The ideal piston, from the viewpoint of cooling, is of course that made of aluminium alloy.

The cooling of oil in the sump can be accomplished most effectively by radiating fins on its outer surface. The lower crankcase should be fully exposed to the outer air. A settling basin for sediment should be provided, having a cubic content of not less than one tenth of the total oil capacity. The depth of this basin should be at least 3 inches and its walls vertical to reduce the mixing of sediment with the oil in circulation. The inlet to the oil pump should be near and above the top of the settling basin. Concerning filtering screens there is little to be said, save that their areas should be ample and the mesh coarse enough (one sixteenth of an inch) to offer no serious resistance to the free flow of cold or heavy oil through them; otherwise the oil in the crankcase may build up above them to an undesirable level. The necessary frequency of draining and flushing out the oil sump differs greatly with the age (condition) of the motor and the suitability of the oil used. In broad terms, the oil sump of a new motor should be thoroughly drained and flushed with kerosene at the end of the first 200 miles, next at the end of 500 miles and thereafter every 2,000 miles.

Now, to answer a leading question that cannot be passed over lightly, namely: "What is the best type of lubricating system for automobile motors?" Without hesitation I would say force feed, i. e., a circulating system with feed under pump pressure to all crank and camshaft bearings. This system furnishes a copious supply of oil for carrying away the friction heat of bearings and for cooling the piston heads. In fact, the large body of oil in constant circulation offers the best conveyance for surplus heat to the outer air. Once the oil sump has been filled, no further attention is required. There is no danger of burning out bearings or scoring cylinders from lack of oil, fouling of plugs or carbon troubles. Furthermore, so long as there is water in the cylinder jackets and oil above the oil pump inlet, no amount of punishment by hard work on the road or high motor speed can injure any of the moving surfaces in contact.

TRANSMISSION AND REAR AXLE.

In the early days grease of medium consistency was thought to be the only proper lubricant for use in transmission and rear axle mechanisms (Fig. 13), but improvements made in the design of different devices for retaining the lubricants where the drive-shafts pass through the case have fortunately made possible the introduction of more efficient semifluid lubricants.

CHEMICAL CONSTITUENTS OF TRANSMISSION LUBRICANTS.

Cup Grease.—Cup grease is manufactured, first, by the saponification of fatty oil with calcium hydroxide ($Ca\ (OH)_2$) in the presence of water. When saponification is complete, hydro-carbon oils are added to the soap formed to make the homogeneous mixture known as cup grease. Light, medium and hard greases are readily made by varying the quantities of the constituents. Finished cup grease always contains more or less water and for that reason when heated it foams and a permanent separation takes place between the soap and the hydro-carbon oil.

Fiber Grease.—Fiber grease is made by the saponification of fatty oil with sodium or potassium hydroxide in the presence of water. When the saponification is completed, all of the water is boiled out and a hydro-carbon oil is then added. Variation in the quantity of the constituents makes possible the manufacture of light, medium and hard grease. This grease when heated up becomes entirely fluid and upon being allowed to cool returns approximately to its former consistency.

Graphite Grease.—Finely divided graphite is mixed with cup grease to form different grades of graphite greases.

Semi-fluid Oils.—These are made in the same manner as cup greases, the only difference being that a smaller quantity of saponified fatty oil is combined with the hydro-carbon oil.

Gear Compounds.—The so-called gear compounds are generally manufactured by blending fiber grease with a hydro-carbon oil. Inferior grades are made from a mixture of paraffin wax and heavy oil. Paraffin not being a lubricant, the lubricating efficiency of such compounds is therefore reduced in proportion to the quantity present.

Transmission Oils.—These oils consist either of a heavy straight cylinder stock (hydro-carbon oil) or of a blend of same with a small percentage of fatty oil, and are used for the most efficient lubrication of both transmission and worm- and bevel-gear rear-axle mechanisms. For the lubrication of worm-driven rear axles, chemically pure castor oil is sometimes used, in spite of the fact that it offers no noticeable advantages over transmission oils and in the face of an almost prohibitive cost.

LIMITING CONDITIONS OF OPERATION.

Doubtless were it not for the frequent serious leakage of lubricant which occurs from the average commercial transmission or rear axle, no other medium would be used than transmission oils. The best body of these oils for use in both winter and summer lies around 140 seconds at 212 degrees (Saybolt universal instrument). Leakage does, nevertheless, occur and is consequently one of the chief factors, if not the leading factor, governing the specification of lubricants for these mechanisms. It is generally recognized to-day that even a medium cup grease is unsatisfactory because of the fact that the gears cut "tracks" into its body, thus preventing anything more than momentary contact with their teeth, and the other parts requiring lubrication. On the other hand, a thin oil rapidly leaks out through the joints of the case and along the shafts. As a solution, a compromise lubricant is chosen which offers the least resistance to movement and shows a minimum loss from leakage. Often a heavy grease mixed with wood fiber, asbestos or other solid matter, is used to suppress the irritating noise of poorly cut gears. Such substances cannot fail to show a material loss in power transmission and are not to be advised.

When cup greases are used alone, the friction heat soon causes a voluminous foaming and, later, a permanent separation of the oil from the soap which occludes it. For this reason cup greases should never be used for transmission or rear axle lubricants in any other form than semi-fluid oils. For leaky cases gear compounds only should be used, due to their high adherence, good lubricating properties and slight tendency to leakage. They may be had in consistencies sufficiently heavy to suit conditions of the leakiest case, without possessing any of the disadvantages of straight cup or fiber greases. Leakage with any lubricant can be reduced to a minimum by the application of centrifugal rings to all shafts, or if the space be too limited for the application, by felt packing, and by providing air vents at the top of the case so as to maintain atmospheric pressure above the lubricant within the case. All lubricants possess a fairly high coefficient of expansion and when filled cold up to the center of the shafts, will be expanded by friction heat and the level raised thereby to such an extent that the hot air above, also expanded, will force them out, even through tight joints.

As to the necessary frequency of inspecting the level of the lubricant in transmission and rear axles, or of draining and flushing out same, it would be merely a waste of words to give any definite figures. There are entirely too many variables involved. Suffice it to say that reasonably frequent attention should be given to maintain a uniform level in these mechanisms, and to drain them whenever a sample of the lubricant shows the presence of considerable metallic dust when examined by reflected sunlight. A thorough cleansing of the case between every three to five thousand miles will richly repay what it costs in lubricant by the increased life of the parts.

CHASSIS.

Cups.—Commercial cup grease of a grade suiting the season should be used, exception being made only of the grease cups feeding the water-pump bearings and glands, where graphite greases give better service.

Steering Gear.—The worm and sector in the steering-gear housing require a cup or fiber grease or a heavy gear compound, depending upon the tightness of the housing. Preference should be given the latter wherever its use is possible.

Wheels.—With anti-friction bearings, a medium grade of fiber grease will give entire satisfaction. In case the wheels are fitted with plain bearings, a suitable grade of semi-fluid oil should be used.

Suspension Springs.—The blades of suspension springs where they come into contact with each other can be

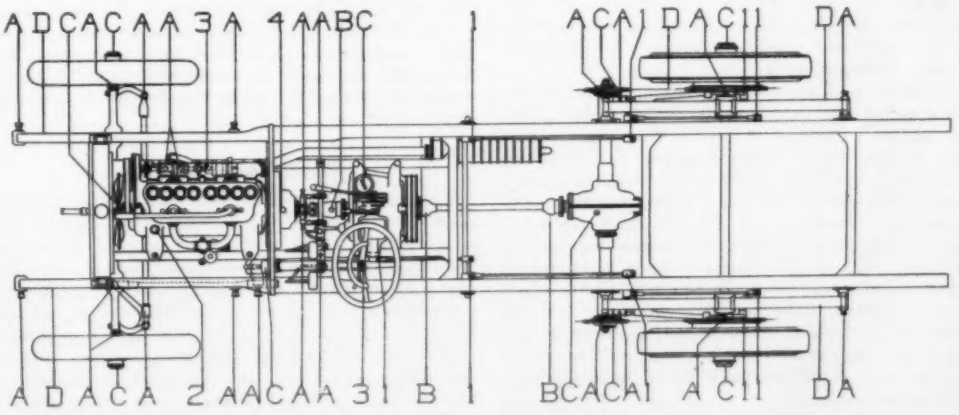


Fig. 14.—Suggested form for lubrication chart, letters designate parts to be supplide with grease at fixed intervals of time or distance traveled. Numerals designate parts to be supplied with oil.

lubricated most effectively by painting their surfaces with a heavy graphite grease. One application only will be necessary between annual overhauls; the improvement in the riding qualities of the car cannot fail to be appreciated.

Moving Parts Exposed to Dust.—Miscellaneous moving parts exposed to dust can best be lubricated by the application of a suitable grade of graphite grease.

CONCLUSION.

There is no valid reason why much greater economy and efficiency of lubrication cannot be attained in all automobile motors, by the simple application of a knowledge of cause and effect of oil destruction. Neither is there any insurmountable difficulty in the way of suppressing useless and costly leakage from all automobile mechanisms. Certainly the almost unbelievable drop in yearly maintenance costs and the total elimination of all lubrication annoyances should make the study and successful solution of this problem one of absorbing interest and profit to every manufacturer and to his customers. Intelligent co-operation between oil refiners and automobile manufacturers would surely do much along this line.

Measuring Growth of a State

First Enumeration Solely to Provide for Political Reapportionment.

THE census enumeration of New York State promises to be, next to that of the United States, the largest and most expensive single statistical enterprise in the country. In no other State are there so many people to be enumerated; while the fact that the number and complexity of the interrogatories will be more extensive this year and a completion within the short space of two months set by the Constitution is necessary, a large number of supervisors and enumerators, clerks, and intrepreters will be required.

The task, in its simplest phase, involves the counting of upwards of the 11 millions of inhabitants now estimated to be in this State.

FIRST STATE CENSUS IN 1782.

Under the first State Constitution a census was taken in 1782, when the Sheriff was required to direct the local constables to take the number of white inhabitants, including refugees, victims of the invasion of the enemy, at the expense of the counties. These returns were to be summarized and filed with the Secretary of State, to be transmitted by him to Congress. A similar enumeration was taken again in 1786, but it was not until the third State census was taken, in 1795, that the law required the Secretary of State to prepare the blanks containing the questions covered by the enumeration. This State first inaugurated the degennial or periodical system of enumeration of the population and resources. In order not to conflict with the Federal system, the State Constitution provided that an enumeration could be taken in the years in which the unit figure five was present.

During the colonial period the provincial governors were required to give account of the progress of the settlements, and in New York colony at least fourteen different counts of population were taken before the Revolutionary War. Since the provision for periodic measurements of the State's growth was inaugurated by the framers of the first Constitution, many foreign countries, States and Territories have adopted similar systems, and at the present time the laws of at least two foreign countries require an enumeration of the population every five years.

BASIS OF POLITICAL REAPPORTIONMENT.

The first census enumeration in New York State was intended solely for political reapportionment. Consequently, the electoral census of 1782, 1786, 1790, 1795, 1801, 1807, 1814, and 1821, taken under the constitutional provision of 1777, limited the scope of such inquiries, in fact, the first three of these were for the counts of these electors distributed into four property classes. The census of 1914, however, was the first to depart from this rule of mere enumeration of the electors and to procure other social information. At that time over a dozen inquiries were added concerning property qualifications, age, sex, number of slaves, etc.

The census of 1821 required additional inquiries, including agricultural and manufacturing questions and other matters considered of relative importance at that time. In 1825 other questions were added to the census of that year, which was the first to be taken under the second Constitution of 1821. These inquiries concerned the enumeration of defective and dependent classes, such as the deaf, dumb, blind, insane, and paupers and since that time care has been taken to obtain information concerning physically and mentally defective classes. Another item included marriages, births, deaths, and in the next census of 1835 little change was made in the scope of this inquiry excepting that certain questions were added concerning the factory and manufacturing interests.

TRADE INQUIRIES INCREASE.

The census of 1845 introduced many inquiries concerning trade, commerce, newspapers, and periodicals. It increased the number of questions relating to agricultural interests. The census of 1855 under the third Constitution of 1846 differed radically from all previous ones in that for the first time the Secretary of State was called upon to undertake the direction of all the work. In the previous enumerations the returns were tabulated by the local enumerators, who were required to report the totals to the county clerk, who in turn forwarded a summary to the Secretary of State's office.

The next two censuses were taken in 1865 and 1875, when the enumerators, acting in the places of the marshals, were called upon to count the population. These census-takers were allowed $3 per day, to be paid by the county, and this was the last occasion in which the census was taken at the entire expense of the locality, although the State at that time contributed $62,555, while at the census of 1875, the first to be undertaken by the State alone, the appropriation was doubled, totalling $138,037. The census of '65 provided for a large number of inquiries concerning soldiers and sailors engaged in the Civil War. There was opposition against the enumeration because of the fear that such information would be used to draft soldiers. In 1885 and 1895 no census was taken, although in 1892 a mere count consisting of seven questions on population was made, when an appropriation of $205,000 was allowed. Since the publication, however, of the last census taken in 1905, the importance of the subject has been more fully recognized, and the amount of attention paid to the census cannot be better shown than in the figures for the number of inquiries made since this last census.

The constitutional provision limiting the time during which census returns are to be made has frequently proved to be insufficient to complete the task, though it is expected that the coming enumeration can be completed within the months of May and June, as the Constitution requires. The system usually adopted in this country of extending the period of enumeration over one month has been termed the census *de jure* as compared with the English system, which is called the census *de facto* method, which latter system begins and completes the enumeration within one day after a previous distribution of the blanks to be filled out by each householder. Such a method, while reducing the number of errors caused by duplication to the minimum, could not be employed in this country, because many sections are thinly populated and difficult of access.

As stated, census enumerators originally were the local constables. Later the law provided for special takers, who were called "marshals," and appointed by the Secretary of State. At the present time these individuals are called supervisors and enumerators, and the law now provides that the Secretary of State shall appoint and prescribe their duties, and have direct control over their work. Circulars of instructions are provided, and all returns are to be tabulated and arranged according to the numbers of inhabitants, exclusive of aliens, and the number of aliens in each village, town, county, city, borough, and the ward of the State.

MACHINE TABULATION.

Tabulating to-day's population statistics within a reasonable length of time would be practically impossible were it not for the modern machine methods necessary for tabulating the different characteristics of the population for which inquiries are made and which must be presented in various combinations with one another. By the method now in vogue all the numerous facts appearing upon the schedules are transferred to the cards, each being represented by a punched hole, the significance of which is determined by its location on the cards, which are run rapidly through tabulating machines to register the data in a variety of combinations.

With this mechanical aid it is possible to complete the tabulation of all the data within the time specified by law. The Constitution in about one half of the States requires the enumeration of the population every ten years, but less than half of the States completed this work in 1905. The original returns of the enumerators during the past century were deposited in the State library, but unfortunately these were destroyed in the fire of 1911, although the summaries made from these returns are now on deposit in the office of the Secretary of State.—*N. Y. Post.*

Porous Boiler Settings

THE heavy brick setting of a steam boiler looks so solid and substantial that not only is the average user of steam deceived as to its ability to keep out air, but the expert, who should know better, has his attention easily diverted from a very important feature in successful boiler operation. To insure efficient and economical operation all air reaching a boiler furnace should be admitted at the proper place, and in the proper quantities, if economical combustion of the fuel is to be secured; and any additional air that finds its way into the furnace through casual entrances simply interferes with both the draught and the proper combustion. It has come to be recognized that brick boiler settings are by no means airtight, but are actually decidedly porous; and this fact was recently visibly demonstrated at an electric power plant in the Middle West. Men were set at work painting a boiler setting with extra heavy stack paint, and before one side had been covered an improvement in the draught could be seen at the draught gage. When both sides had been painted the natural draught had increased by 0.15 inch.

That this point is so commonly overlooked is not surprising when we constantly see the ruinously cracked brickwork around boilers that is allowed to stand year after year without attention.

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Table of Contents

	PAGE
The Chemical Industries of Germany.—II.—By Prof. Percy F. Frankland	402
Purchasing Coal on Heat Unit Basis	403
Forging Shrapnel Shells.—By Douglas T. Hamilton.—6 illustrations	404
Plating by Impact.—2 illustrations	406
The Largest American Gas Engine.—2 illustrations	407
Death of Pierre-Emile Martin	407
Light-strokes	407
Flying-boat Hulls	407
The Art of Mobile Color.—By M. Luckiesh.—3 illustrations	408
Radium Treatment of Cancer	409
Floor Surfaces in Fireproof Buildings.—By Sanford E. Thompson	410
High-speed Engines	411
Railway Rail Production and Failures	411
Automobile Lubrication.—II.—By C. W. Stratford.—4 illustrations	412
Measuring Growth of a State	414
Porous Boiler Settings	414
Index	415-16

The Scientific American Supplement Index for Vol. 79

JANUARY—JUNE, 1915

THE * INDICATES THAT THE ARTICLE IS ILLUSTRATED

A

Accidents, conditions of industrial 179
Accidents, and science of preventive medicine 265
Acetylene (oxy) welding.....*132
Achievement, a record of in U. S., I, 210; II, 234
Acid, hydrofluoric 140
Advances in photography, recent *44
Aerological service, Italian..... 356
Aeronaut, health requirements for 45
Aeronautic research, scientific..*364
Aeronautical laboratories, European .....I, *328; II, *340
Aeronautics and the war 114
Aeronautics, progress in air-raids 250
Aeroplane darts and fire darts..*124
Aeroplane, developed from a seed-pod *284
Aeroplanes, Italian military....*301
Agricultural fertilizers 130
Agriculture, electric power for.. 106
Airship in the field, Zeppelin...*200
Albumen needed in our diet.... 327
Alloys and metals, British..... 343
Alpha rays and electrical conductivity 191
Aluminium, importance of..... 66
Ammunition, baskets for German 68
Analysis, tide. An inexpensive apparatus 347
Animals, thinking 119
Anisotropy of liquid crystals, optical 80
Antiseptics, manufacture of.... 282
Apparatus for demonstrating Newton's laws..... *42
Arc carbons, chemistry of flaming 122
Arc, temperature of the mercury 107
Arctic, astronomy in the 39
Arithmetical machines, I, *59; II, *75
Artificial production of caoutchouc 399
Artificial production of vigorous trees 150
Artillery and mathematics, science of 143
Astronomical and mathematical research 168
Astronomy, Arthur von Auwer's 279
Astronomy in the Arctic..... 39
Athlete and scientist.....*289
Atmosphere, formation of ozone in upper .....I, 286; II, 303
Atom (nucleus) evidence for existence of 194
Atoms and ions....I, *274; II, *290; III, *310; IV, *326; V, *346; VI, *362
"Atoxicafe" 221
Automobile, Belgian armored, with machine gun *273
Automobile, buying a second-hand *260
Automobile lubrication, I, *392; II, *412
Auwers, Arthur von 279
Auxiliary military motor cars...*113

B

Bacteria, discoveries about 87
Bacteria, mutation and modification of 319
Bananas, unloading by machinery *209
Bank, an inventors' 262
Baskets for German ammunition 68
Beachy (Lincoln) monoplane...*237
Beer yeast dried as article of food 311
Beets, cement from 61
Bell (Liberty) and diseases of metals *236
Bends, effects on electrical conductors *173
Biochemical systems 131
Biologic examinations, personal. 146
Biplane, the Thomas military tractor *254
Bird forms of prehistoric times *52
Birth-time of the world..... 77
Blades, Damascus 200
Blades of steam turbine, keeping clean 334
Blast furnaces, gas from I, *93; II, *110; III, *126; IV, *142
Blind alley job and educational scrap heap 170
Blind, printing for the..... 247
Boat hulls, experiments with flying *148
Boats (snag) on flood rivers...*145
Body, equilibrium of the..... 251
Boiler furnaces, coal combustion in 359
Boiler settings, porous 414
Boilers, protecting steam 315
Books, new, etc., review of..64, 128, 144, 176, 192, 208, 224, 256, 272, 384
Bose (Prof.), scientific work of 291
Bose, Dr., visit to America.... 16
Bread from stones 223
Bricks, translucent glass..... 3
Bridge, Luxembourg 315
Buildings, problem of high..... 368
Bullets and dum-dums, high-speed 304
Bureau of mines, report 35
Business aspect of the kelp proposition 71
Business of the Panama Canal.. 240

C

Cables underground, effect of earth moisture on temperature of 243
Calendar, perpetual, and table.. 140
Calendars: correspondence 283
Camp engineering, water purification 383
Cancer, radium treatment of.... 409
Cancer, what everyone should know about 231
Canning pineapples, utilizing wastes in 361
Cannon ball tree, tropical America *92
Caoutchouc, artificial production of 399
Cars, German auxiliary military motor *113
Cartridge, the hydraulic mining.*156
Cathode rays, salts colored by.. 318
Causes of solar heat..... 91
Cell making, selenium..... 187
Cellars, concrete wine..... 29
Cement from beets 61
Cement manufacture, cost of... 400
Central Asia, scientific exploration of 349
Centrifugal pump, the largest.. *33
Ceylon, pearl fisheries of..... *4
Chalk fuel and peat..... 352
Chart of automobile construction *260
Chemical elements and evolution 282
Chemical industries of Germany, I, 389; II, 402
Chemist and industrial development of U. S. .....I, 210; II, 234
Chemistry of flaming arc carbons 122
Chemistry of incandescent gas mantle 139
Cipher, science of the.....*394
Climate and location of manufacturing plants 219
Clusters, star 388
Coal analysis, phenol for..... 339
Coal and electric heaters, efficiency of 181
Coal combustion in boiler furnaces 359
Coal mined by machines 395
Coal, purchasing, on heat unit basis 403
Coal substitutes. Chalk fuel and peat 352
Coal tar, new knowledge of..... 222
Coal the big item 125
Coal, unit 397
Coaling United States warships.*276
Cobalt steel 379
Coffee, harmful constituents of roasted 221
Coil, inductance of a 48
Color photography 134, 381
Color, art of mobile..... 408
Color sensitized plates 240
Combustion, advantages of surface 150
Compass, prismatic *356
Concentration and co-operation in science 138
Concrete viaducts on Pennsylvania Railroad *17
Conductors (electrical), effects of bends on *173
Conformator and the ergograph.*289
Coolidge tube in metallurgical research 331
Copper cyanide plating solutions 302
Copper plating and silvered mirrors *28
Correspondence: Curious property of numbers 371
Correspondence: Flying boat hulls 407
Correspondence: Oil filters. Calendars 283
Correspondence: Rifling cannon 334
Correspondence: Safe and Unsafe oxy-acetylene generators 371
Correspondence: Submarine navigation 333
"Cracking" heavy oils, and gasoline 283
Crane, electric-steam wrecking..*285
Cranes, monorail electric 98
Crime, effect of war upon..... 121
Crude oil, gasoline from "synthetic" 189
Crystal (liquid) changes in form *43
Crystals, optical anisotropy of liquid 80
Crystalline structure and X-rays 5
Cuba by rail *40
Culture-electro, literature of... 258
Cupola, a handy foundry..... 219
Customs duties, apparatus determining *193
Cutlery works of Thiers *177
Cyanide plating solutions, copper 302

D

Dam, the Gatun..... 247
Damascus blades 200
Dangers of London traffic..... 213
Darts, aeroplane and fire.....*124
Defense of Belgium by inundation *166
Deformation of earth by the moon 167
Diary of Kilauea, the *36
Diet, albumen needed in our.... 327
Diffraction patterns, X-ray..... 83
Disease (hookworm) and rural school *164
Disease, use of light in treatment of 255
Diseases dangerous at different periods of life 149
Diseases, transmission of malaria 50
Disorders, pathology of mental, I, 306; II, 335
Distances, measurement of, in war *324
Divers, great toothed of America *52
Dosage of radium emanation, uniformity in 123
Dreadnought (super), "Queen Elizabeth" *299
Dual personalities, instances of, I, 2; II, 25
Dum-dums and bullets, high-speed 304
Dyestuff industry 336
Dyestuff situation, the 278

E

Earth by the moon, deformation of 167
Earth (radio-active) and plant growth .....I, *216; II, *228
Earth, radio-telegraphy of the.. 29
Earth, the, considered as a heat engine 391
Earth, watching it revolve.....*196
Earthquakes, protection from... 90
Earth's crust, tides in the.....*382
Earthworms, peculiarities of.... *23
Educational scrap heap and blind alley job..... 170
Electric cranes, monorail..... 98
Electric generators, big 383
Electric power for agriculture.. 106
Electric-steam wrecking crane..*285
Electric towing in Panama Canal locks *65
Electric transformer explosion.. 89
Electric waves and oscillations. 154
Electrical conductivity and alpha rays 191
Electrical engineering and race progress 307
Electrical science in 1914, applied 51
Electrically driven warship..... 53
Electricity and steel making...*206
Electricity, system of generating 16
Electrification of the Elkhorn grade *372
Electrification project for great railway *49
Electro-chemical generators 71
Electro-culture. Literature of. 258
Electro-culture of the soil..... 151
Electrolysis, iron manufacture by *70
Electrolytic iron melted in vacuo 247
Electrolytic iron, quality of.... 205
Electrolytic silver-cleaning method 40
Electro-magnet for removing metal from wounds *161
Electromagnetism, developments in .....I, 338; II, 366
Electrometallurgy ...I, 378; II, 398
Electrometer, a vibration..... 330
Elkhorn grade, electrification of*372
Employees, waste in hiring and discharging 102
Energy, wireless transmission of, I, *252; II, *270
Engine, installation of gas..... 55
Engine, the earth as a heat.... 391
Engineer in the field, the..... 98
Engineering electrical, and race progress 307
Engineering and science, recent developments in 82
Engineers' difficulties with tropical telephones 355
Engines, high speed 411
Enzymes, the function of..... 67
Equilibrium of the body..... 251
Equipment, utilizing old..... 127
Eruptions and earthquakes, the Sakurajima *241
Ethiopian arts and sciences, Meroë *97
Eugenics and war 230
European war and potash supplies 86
Evolution of the elements: the evidence of the stars 282
Evolution, some questions of... 215
Examinations, personal biologic 146
Expedition, relics from Grinnell's second 300
Expedition, Roosevelt-Rondon scientific .....I, *248; II, *268
Exploration in Central Asia, scientific 349
Explorers, food for polar..... 36
Explosion of an electric transformer 89
Explosion, gaseous 288
Explosives (high) in warfare... 117
Exposition illumination, Panama-Pacific *369
Exposition of military sanitation*305

F

Faunal conditions (new) in canal zone *106
Fear, hypnosis or agony of..... 96
Features of photo-chemistry, some 27
Fence, dog-proof 43
Fertilizer for wartime in Germany 99
Fertilizers, agricultural 130
Fertilizers, radio-active 53
Field, a Zeppelin airship in the.*200
Films (paint), iron and steel protection 160
Filters, oil 66
Firearms, rifling of *277
Fire and aeroplane darts *124
Fire-resisting wood 69
Fire service fittings and hose couplings 304
Fixation of atmospheric nitrogen 388
Flashlight signals on the Boston & Maine 288
Flat wheels, impact from..... 85
Floor surfaces in fireproof buildings 410
Flowers, experiments in hybridizing Japanese 18
Flying boat hulls, experiments..*148
Flying boat hulls..... 407
Food, dried beer yeast as article of 311
Food, plancton the ultimate.... 66
Food for polar explorers..... 36
Food products, preserving of... 117
Food, resources of the ocean... 66
Forests, preserving the 29
Foundry cupola, a handy..... 219
Freight carrying on the Great Lakes *360
Freight handling by motor trucks 58
Fuel in Germany, motor..... 55
Fuel oil 325
Fuel oil in the Navy..... 218
Fuel oil on railroads..... 203
Function of enzymes, the..... 67
Furka Railway, Alpine.....*338
Future of science 370

G

Gardens of Zoological Society, London *180
Gas from blast furnaces..I, *93; II, *110; III, *126; IV, *142
Gas and steam engines and the turbine 294
Gas engine, the largest American *407
Gas engine, installation of..... 55
Gas mantle, chemistry of incandescent 139
Gas, removing tar from..... 330
Gases (rare) and hydrogen.... 191
Gaseous explosions 288
Gasoline locomotives 243
Gasoline manufacture by "cracking" heavy oils 283
Gasoline from "synthetic" crude oil 189
Gatun dam 247
Generators, big electric..... 383
Generators, electro chemical.... 71
Generators, oxy-acetylene, correspondence 371
Geographic influence, problems of 374
Geologic time and sea-salt..... 79
Geology of Yellowstone National Park *1
German railways and the war.. 254
German system and method..... 155
Germany's chemical industries, I, 389; II, 402
Glucose (commercial) and its uses 314
Golf ball, flight of..... 158
Grain port of Russia, Odessa... 3
Grass, sub-tropical hay..... 3
Gravitation, modern theories of 317
Great Lakes, freight carrying on*360
Great toothed divers of America *52
Grinnell's second expedition, relics 300
Guidance (vocational) why?... 275
Guide lights on aviation fields.. *29
Gun powder, what happens when it explodes 246
Guns (big) wire winding for Uncle Sam *332
Guns, the making of large *115
Gunshot wounds in war..... 309
Gyroscopic phenomena *380
Gyrostatic action...I, *172; II, *188
Gyrostats and their lessons.... 238

H

Harvest forecasts for 1915..... 325
Havana and Key West joined... *40
Hay grass, sub-tropical 3
Health requirements for the aeronaut 45
Heat, causes of solar..... 91
Heat engine, the earth as a.... 391
Heat, storing 22
Heaters (electric) and coal efficiency 181
Hemp growing in America.....*308
High building, problem of..... 368
High explosives in warfare..... 117
High speed engines..... 411
History of opium 350
Home, the hygienic..... 74
Home lighting, economies of....*198
Hookworm disease and rural school *164
Horse-power and the kilowatt.. 162
Hose couplings and fire service fittings, national standard... 304
Hospitals and fields, X-ray work in war times *120
Hour angle observation of Polaris, daylight 263
Hulls (flying boat) experiments*148
Hulls, flying boat: correspondence 407
Hybridizing Japanese flowers, experiments in 18
Hydraulic mining cartridge.....*156
Hydraulic plant, a unique..... 127
Hydrofluoric acid 140
Hydrogen and the rare gases... 191
Hydrogen, technical production and uses 153
Hydrogen X-ray tube, new..... *71
Hygienic home, the 74
Hypnosis or agony of fear..... 96

I

Ideas (modern) on end of the world 178
Illumination of Panama-Pacific Exposition *369
Impact from flat wheels 85
Inductance of a coil 48
Industrial accidents, conditions of 179
Industries of Germany, chemical, I, 389; II, 402
Industry and technics (Roman) in early Germany *129
Insects, sense of smell in..... 80
Installation of gas engine..... 55
Instantaneous photography without camera or plate *125
Instruments of precision, new.. 368
Insurance laws, protection of the strong 343
Inundation, defense of Belgium by *166
Inventions of Edward Weston..*198
Inventors' bank 262
Ions and atoms ...I, *274; II, *290; III, *310; IV, *326; V, *346; VI, *362
Iron (electrolytic) melted in vacuo 247
Iron manufacture by electrolysis *70
Iron and steel protection by paint films 160
Irrigation, light and power in California 143
Irrigation with fresh water from the sea 84
Italian aerological service 356
Italian military aeroplanes.....*301

J

Japanese flowers, hybridizing experiments 18
Jupiter, the planet *20

K

Kelp proposition, business aspect of 71

Kerosene lamps, explosion of... 92
Kilauea *36
Kilowatt and horse-power..... 162
Koepsel permeameter 197

L

Laboratories, European aeronautical .....I, *328; II, *340
Lahun, the treasure of.....*257
Lamps, behavior of incandescent 195
Lamps, explosion of kerosene... 92
Letters, an insoluble seal for.. 138
Liberty Bell and diseases of metals *236
Life-study of patients 226
Light, power and irrigation in California 143
Light in the treatment of disease 255
Light stroke 407
Lightest known wood 96
Lighting, economies of home....*198
Lighting, safety in good 363
Lightning rods 397
Lights (guide) on aviation fields *29
Liquid crystals, changes in form *43
Liquid crystals, anistropy of... 80
Living tissues outside the body, cultivation of 354
Location of manufacturing plants and climate 219
Locomotive headlights 16
Locomotive headlights, battery-operated 322
Locomotives, gasoline 243
Longitude, Washington-Paris by radio signals..... 266
Lubrication, automobile, I, *392; II, *412

M

Machines, arithmetical, I, *59; II, *75
Machines, coal mined by..... 395
Magnetic permeability, temperature coefficient of 283
Making of large guns.....*115
Malaria and transmission of diseases 50
Mantle, chemistry of incandescent gas 139
Manufacture of shrapnel *385
Manufacturing plants, effect of climate on location of..... 219
Maps and map making..... 38
Martin, Pierre-Emile, death of.. 407
Mathematical and astronomical research 168
Mathematics and artillery science 143
Measurement of short intervals of time 379
Measurements of distances in war *324
Medicine (preventive) and accidents 265
Mental disorders, pathology of, I, 306; II, 335
Mercury arc, the temperature of 107
Meroë, the royal city of Ethiopia *97
Metallurgical research, Coolidge tube in 331
Metals and alloys, British 343
Metals diseases of, and Liberty Bell *236
Metals in wounds, locating..... 96
Metals (refractory) and the war 169
Metals rust proofing, sherardizing for *212
Military aeroplanes, Italian *301
Military motor cars, auxiliary..*113
Military sanitation, exposition of*305
Military surgery 54
Military tractor biplane, the Thomas *254
Mines, report of bureau..... 35
Mining cartridge, the hydraulic*156
Mirrors silvered, protected by copper plating *28
"Mjolner and Mimer" steamers. 291
Mobile color, the art of *408
Modern ideas on end of the world 178
Moisture (earth) and underground cables 243
Monoplane, the Lincoln Beachey*237
Motion pictures, the romance of 323
Motor cars, German military auxiliary *113
Motorcycle street sweeper 395
Motor fuel in Germany 55
Motor truck in modern military service *273
Motor trucks, handling freight by 58
Motors, new three-phase 92
Moving picture machines, stop motion *396
Municipal service, training for in German cities 118
Muscle fatigue, radio time signals *152
Museums, making them useful..*348
Mutation and modification of bacteria 310

N

Narcotics, how they affect plants 267
Naval warfare and the submarine .....I, *296; II, *312
Navy, fuel oil in the 218
Nebulæ, the planetary 287
Nepal, on borders of India *353
Newton's laws, apparatus for demonstrating *42
Nitrogen, fixation of atmospheric 388
North pole, stars around the... *13
Nottingham, to make it a port. 342
Nucleus atom, evidence for existence of 194
Numbers, curious property of: correspondence 371
Nutrition, new era in science of 182
Nutrition; salt and its relation to 295

O

Odessa, grain port of Russia... 3
Oil filters 66
Oil filters: correspondence..... 283
Oil fuel 325
Oil fuel, on railroads 203
Oils (heavy) "cracking" of, for gasoline 283
Opium, the history of 350
Optical anistropy of liquid crystals 80
Ores, metals out of..I, 378; II, 398
Origin of the Rocky Mountains .*81
Oscillations and waves, electric 154
Oxy-acetylene generators: correspondence 371
Oxy-acetylene welding *132
Ozone formation in upper atmosphere .....I, 286; II, 303
Ozone in ventilation 34
Ozone sterilizing plant..... 322

P

Paint films, and iron and steel 160
Panama Canal, business of the 240
Panama Canal locks, electric towing in *65
Panama Canal Zone, new faunal conditions *106
Panama-Pacific Exposition, illumination *389
Parsons marine turbines 71
Patents and their purpose. Historic notes 354
Pathology of mental disorders, I, 306; II, 335
Patients, life-study of 226
Pearl fisheries of Ceylon..... *4
Pearls, artificial production of..*140
Peat and chalk fuel..... 352
Pennsylvania Railroad concrete viaducts *17
Periscope, various forms of the.*322
Permeability, temperature coefficient of magnetic 283
Permeameter, Kolsepel 197
Perpetual calendar and table... 141
Personal biologic examinations. 146
Personalities, instances of dual, I, 2; II, 25
Petroleum conditions in Russia 197
Phenol for coal analysis 339
Philosophy and technics 124
Photo-chemistry, some features of 27
Photographing projectiles, I, *204; II, *220
Photographs, stereoscopic 51
Photography, color 134, 381
Photography, recent advances in *44
Photography without camera or plate, instantaneous *125
Photokaleidograph for picture production *12
Physiological puzzle *133
Physiology of worry 21
Pineapples, utilizing wastes in canning 361
Plancton, the ultimate food.... 66
Planet Jupiter, phenomena of.. *20
Planetary nebulæ 287
Planets (reaction) and the sun, I, 186; II, 202
Planets, testing sensibility of...*244
Plant growth and radio-active earth .....I, *216; II, *228
Plants, how narcotics affect.... 267
Plates, color sensitized 240
Plating, by impact *406
Plating solutions, copper cyanide 302
Polar explorers, food for 36
Polaris, how to find by daylight. 263
Police arm, the future of..... 174
Potash supplies and the European war 86
Potatoes, plant only certified... 28
Pottery industry of the United States 263
Precision, new instruments of.. 368
Preserving of food products ... 117
Printing for the blind 247
Prismatic compass *356
Prisoners, employment of war.. 54
Problems of geographic influence 374
Projectiles, photographing, I, *204; II, *220
Properties of selenium 103
Protection against torpedoes.... 107
Protection from earthquakes... 90
Protection of the strong. Insurance laws 343
Pump, the largest centrifugal... *33
Purification of water by ultra-violet rays *10
Purpose of patents. Historic notes 354
Puzzle, physiological *133
Pyramid (plundered) of Lahun.*257

Q

"Queen Elizabeth" super-dreadnought 299

R

Race progress and electrical engineering 307
Radio-active earth on plant growth, influence of, I, *216; II, *228
Radio-active fertilizers 53
Radio-telegraphy and the Earth 29
Radio time signals, records of..*152
Radium emanation, uniformity in dosage of 123
Radium, measurements of..... 327
Radium treatment of cancer.... 409
Rail, to Cuba by *40
Railroad electrification in the far west *49
Railroads, fuel oil on 203
Rails, making safe steel.....*100
Railway, Furka, Alpine *338
Railway rails—production and failures 411
Railways (German) and the war 254
Rangefinders 28
Receiver, new telephone..... 67
Record of achievement (chemist), ...I, 210, II, 234
Refractory metals and the war 169
Relation of horse-power to kilowatt 162
Relics from second Grinnell expedition 300
Removing particles of metal from wounds *161
Research, astronomical and mathematical 168
Research, scientific aeronautic..*364
Rifling cannon: correspondence. 354
Rifling of firearms *277
Rignoux's telephotographic apparatus *321
Rivers, snag boats on flood.....*145
Rocky Mountains, origin of.... *81
Roentgenology in war *68
Roman technics and industry in early Germany *129
Romance of motion pictures.... 323
Roosevelt-Rondon scientific expedition .....I, *248; II, *268
Ropeway, a new passenger..... 160
Rural school and hookworm disease *164
Rust-proofing metals; Sherardizing *212
Rubber, artificial production of. 399

S

Safe steel rails, making *100
Safety in good lighting 363
Sakurajima eruptions and earthquakes *241
Salt and its relation to nutrition 295
Salts colored by cathode rays... 318
Salving sunken submarines.....*225
Sanitary exhibition at Berlin ..*305
Saturn, measurements of the planet 391
Science and engineering, recent development in 82
Science and the tariff.....*193
Science, applied electrical in 1914 51
Science, concentration and co-operation in 138
Science, future of 370
Science, mathematics and artillery 143
Science of nutrition, new era of. 182
Scientific aeronautic research...*364
SCIENTIFIC AMERICAN SUPPLEMENT. Back numbers.240, 256, 272
Scientific exploration in Central Asia 349
Scientific work of Prof. J. C. Bose 291
Scientist and athlete *289
Sea salt and geologic time..... 79
Seal, insoluble for letters 138
Seals, ancient wax 395
Seals, old English 185
Selenium, cell making 187
Selenium, properties of..... 103
Sense of smell in insects 80
Sensibility of plants, testing the*244
Sensitized color plates 240
Sherardizing for rust-proofing metals *212
Shipping tonnage, British 360
Ships, "suction" between passing .....I, *30; II, *46; III, *62
Shrapnel and shrapnel manufacture *385, *404
Signals (flashlight) on Boston & Maine 288
Signals (radio) for Washington-Paris longitude 266
Signals, records of radio-time..*152
Signals, strength of wireless... 377
Silver cleaning, electrolytic method 40
Silver and iodine voltameter.... 167
Silvered mirrors protected by copper plating *28
"Sleep (twilight)" in light of day 112
Smell, sense of, in insects..... 80
Snag boats on flood rivers.....*145
Snow removal 159
Soil, electro-culture of the..... 151
Soil, organic matter in the..... 22
Solar heat, causes of..... 91
Spectrometer, the X-ray *19
Spectrum, Schumann region of.. 254
Spider web spinning *136
Spinning of a web *136
"Standardizing" art of voice production 137
Star clusters 388
Stars around the North Pole... *13
Stars, the evidence of: evolution of the elements 282
State, measuring growth of a.. 414
Steam boilers, protecting 315
Steam engines, gas, and the turbine 294
Steam turbines and effects of vacuum 69
Steamers, the "Mjolner" and "Mimer" 291
Steel casting, X-ray inspection of a *84
Steel, making by electricity....*206
Steel rails, making safe.....*100
Stereoscopic photographs 51
Sterilization of water-supplies for active service troops..... 292
Stones, bread from 223
Stop motion for moving picture machines *396
Storing heat 22
Submarine in naval warfare, I, *296; II, *312
Submarine navigation: correspondence 333
Submarines, salving sunken....*225
"Suction" between passing ships, I, *30; II, *46; III, *62
Sun, reaction of planets upon, I, 186; II, 202
Super-dreadnought *299
Surgery, military 54
Sweeper, motorcycle street 395
Synthetic crude oil, gasoline from 189
System and method, German... 155
System of generating electricity 16

T

Tar (coal), new knowledge of... 222
Tar from gas, removing..... 330
Target ranges in Belgium, model 165
Tariff and science *193
"Taube," evolution of the Etrich*284
Technics and industry (Roman) in early Germany *129
Technics and philosophy..... 124
Teeth, recognizing vocation from*300
Telegraphy, wireless, review of 99
Telemeter measurements in war*324
Telephone receiver, new..... 67
Telephones, engineers difficulties with tropical 355
Telephony, wireless, Marconi and Kuhn 121
Telephotographic apparatus, Rignoux's *321
Temperature coefficient of magnetic permeability 283
Temperature of the mercury arc 107
Testing sensibility of plants...*244
Thermometry, Wheatstone bridge for resistance 148
Thiers, the cutlery works of....*177
Thomas military tractor biplane.*254
Three-phase motors, new 92
Thunder 175
Tide analysis. Simple apparatus for 347
Tides in the earth's crust.....*382
Time (geologic) and sea-salt.... 79
Time, indicating and recording.. 299
Time, measurement of short intervals 379
Time system of the United States 375
Timepieces, Government to certify 155
Tissues, cultivation of living outside the body 147
Torpedoes, etc.; and gyrostatic action .....I, *172; II, *188
Torpedoes, protection against.. 107
Towing in the Panama Canal locks *65
Tractor biplane, the Thomas military *254
Traffic dangers, London 213
Training for the municipal service 118
Translucent glass bricks 3
Treasure of Lahun *257
Tree, cannon ball of tropical America *92
Tree planting, encouraging 99
Trees, artificial production of vigorous 150
Trinitrotoluene in the war 171
Truck (motor) in modern military service *273
Trucks handling freight by motor 58
Tubes, X-ray developments..... 183
Turbine steam, keeping blades clean 334
Turbines, effects of vacuum on steam 69
Turbines, Parsons marine..... 71
"Twilight sleep" in light of day 112

U

Ultimate food, Plancton..... 66
Ultra-violet rays, purification of water *10
Underground cables, earth moisture and temperature 243
Uniformity in dosage of radium emanation 123
Unit coal 397
United States time system, the 375

V

Vacuo, electrolytic iron melted in 247
Vacuum, effects of on steam turbines 69
Vault, the strongest in the world*169
Ventilation and fresh air 74
Ventilation, ozone in 34
Viaducts of concrete, Pennsylvania Railroad *17
Vibration electrometer 330
Vocational guidance, why? 275
Vocations from the teeth, recognizing *300
Voice production, "standardizing" the art 137
Volcano and earthquakes, Sakurajima *241
Voltameter, silver and iodine... 167

W

War and aeronautics 114
War and eugenics 230
War, effect of crime upon..... 121
War, measurement of distances in *324
War prisoners, employment of.. 54
War, Roentgenology in *68
War, X-ray work in *120
Warship, electrically driven ... 53
Warships, coaling United States*276
Wartime fertilizer in Germany. 99
Washington-Paris longitude by radio signals 266
Waste in hiring and discharging employees 102
Watch, use and care of a..... 233
Watching the earth revolve.....*196
Water purification. Camp engineering 383
Water purification by ultra-violet rays *10
Water supplies, sterilization of, for active service troops..... 292
Waves and oscillations, electric. 154
Wax seals, ancient 395
Web, the spinning of a.....*136
Welding, electro-percussive 299
Welding, oxy-acetylene *132
Weston's (Edward) inventions..*108
Wheatstone bridge for resistance thermometry 148
Whetstones in United States National Museum 275
Wine cellars, concrete 29
Wire winding big guns for Uncle Sam *332
Wireless military outfit 119
Wireless signals, strength of... 377
Wireless telegraphy, review of.. 99
Wireless telephony, Marconi and Kuhn 121
Wireless transmission of energy, I, *252; II, *270
Wood, fire-resisting 69
Wood pulp shortage threatened 83
Wood, the lightest known..... 96
World, birth-time of the 77
World, modern ideas on end of the 178
Worry, the physiology of..... 21
Wounds in war, gunshot 309
Wounds, locating metals in..... 96
Wounds, removing particles of metal from *161
Wrecking crane, electric-steam..*285

X

X-ray diffraction patterns 83
X-ray inspection of steel casting *84
X-ray spectrometer *19
X-ray tube, new hydrogen *71
X-ray tubes, recent developments 183
X-ray work in war *120
X-rays and crystalline structure 5

Y

Yeast (beer), dried as food 311
Yellowstone National Park, geology of *1

Z

Zeppelin question, the 214
Zoological Society Gardens of London *180